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High tension high tensile fencing



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High tension high tensile fencing

D.A. QUINTON
Range Research Station
Kamloops, British Columbia

Research Branch
Agriculture Canada
1983

Copies of this publication are available from:
Dr. D.A. Quinton
Range Research Station
Research Branch, Agriculture Canada
3015 Ord Road
Kamloops, British Columbia
V2B 8A9

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SUMMARY

Many fence designs in use in Canada today are carry-overs from early traditions and technology. These fences are expensive, labor intensive and in most cases, overdesigned. Research has resulted in new technology, new materials and in a better understanding of the capabilities and functions of nonelectric fence materials and fences. This bulletin outlines new advances in fencing technology and construction methodology. Implementation of construction technology alone can reduce fencing costs by 40%. Even greater savings can be achieved by using new materials. This bulletin will aid anyone concerned with non-electric fencing, whether advising producers or erecting a fence.

RESUME

La conception de nombreux types de clôtures en usage au Canada est fondée sur des traditions et une technologie désuètes. Ces clôtures coûtent cher, nécessitent beaucoup de main-d'oeuvre et sont, la plupart du temps, trop compliquées. Des études ont permis d'élaborer de nouvelles techniques, de mettre au point de nouveaux matériaux et de mieux comprendre les possibilités et les fonctions des clôtures non électriques. Le présent bulletin expose les progrès réalisés dans les techniques de construction des clôtures. La seule application de ces dernières peut réduire le coût de construction des clôtures de 40% et des économies encore plus substantielles peuvent être réalisées grâce aux nouveaux matériaux mis au point. Cette publication sera utile à quiconque est appelé à conseiller les agriculteurs sur la construction de clôtures non électriques ou à en construire.

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I N T R O D U C T I O N

Fences are a vital part of livestock and forage systems. Although they are primarily used to confine or exclude various kinds and sizes of livestock, they are also important in influencing animal movements and behaviour. Without good fences there would be no protection for crops, no control over breeding, feeding or safety of livestock and no established rangeland boundaries.

Originally, fences consisted of stone or log walls placed around highly productive fields and buildings for protection. Fencing then evolved into a management tool used to obtain more benefit from less productive lands. This first became practical on an extensive scale with the introduction of barbed wire in the late 19th century and the introduction of woven wire a few years later. After the introduction of cheap wire, there was minimal development in fencing technology or in understanding of the role of fence components. Posts were spaced one log apart and wires were tightly attached to them to simulate the rigidity of logs. Posts were eventually treated to curtail rot, were sharpened and set by pounding rather than by backfilling and tamping, but little else was changed until recent years.

Today's high costs for land, machinery, fertilizer, fuel, feed and farm materials, as well as for labour, have dictated more efficient use of land. These economic conditions plus the need for replacement of many fences erected in the 1940's, with inexpensive labour and materials, have intensified the need for good low cost fences. This has, in turn, led to research to identify what constitutes good fences and fencing methods. This research has led to the use of high tension fences constructed of either barbed wire or high tensile smooth wire and to electrification of the latter. The best fence is the lowest cost fence that will do the required job over the greatest period of time.

F E N C E C O M P O N E N T S

The basis of a modern fence is a pair of anchors, "brace assemblies", between which wires are strung. Posts are set in line between the brace assemblies to maintain wire spacing and to support the wires. The wires are loosely attached to the posts with staples. Wire spacing is further stabilized

by the attachment of droppers or stays. All of these components act together as a unit in which resilient materials, correct anchoring and a good right of way are exploited to produce an economical and effective fence.

BRACES

To understand fence function and performance, it is necessary to have a knowledge of the forces placed on a fence. Most 12½ gauge wire used today has a breaking strength of 450 kg for barbed wire and 590 kg for smooth (high tensile) wire. A brace assembly with five wires attached, each tightened to 136 kg tension will thus have to hold a sustained force load of 680 kg. The brace assembly, being the anchor for the fence, and the component giving strength to the fence, must withstand the tensioned force of the wires plus any additional forces up to the point at which the wires break.

POSTS

Posts and their setting are the most expensive items in fence construction. Therefore, the fewer posts required, the less expensive a fence will be. The primary functions of line posts are to maintain proper wire spacing, absorb some of the weight of the wire, prevent overturning and add visibility to the fence; they are not required to add appreciable strength or rigidity to the fence. Thus line posts can be spaced at intervals from 10 to 30 m apart. The actual post spacing is dependent upon the terrain and the purpose of the fence. Research has shown that fencing costs are not appreciably reduced with post spacings greater than 18 m. (Fig. 1).

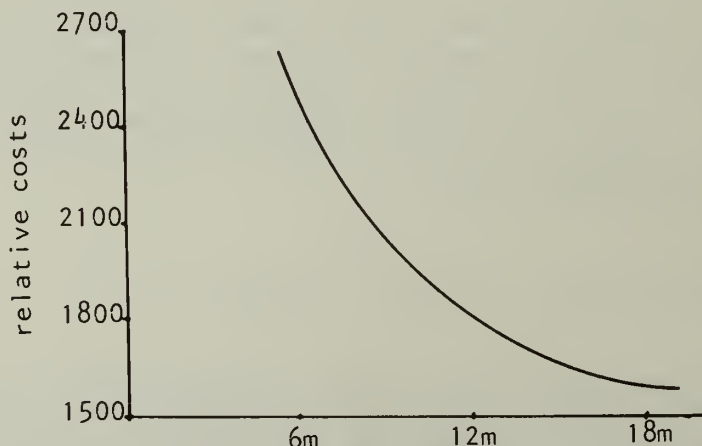


Figure 1. Post spacing versus fence costs

WIRE

Wire is a restraining tool that plugs the holes between posts and brace assemblies. Fence wire should be sufficiently elastic to withstand applied stress forces and should be galvanized to retard rust. Barbed wire must be prestressed to 270 kg to straighten the twists before it will behave elastically to applied forces. High tensile wire, being a single strand, does not need prestressing. Wire should be attached firmly to brace assemblies at a standard tension of 136 kg at 0°C or equivalent.

The barbs on wire are essentially a hold over from the days of low tensile strength wire when it was believed that they were an important deterrent to animals. Research has shown that the elastic, unified performance of modern fence designs is a more effective deterrent. A panel of wire fence, cross braced with droppers, moves with the animal challenging it, yet does not allow the wires to be spread and the fence breached.

STAPLES

Staples or fasteners are the means by which wire is attached to brace assemblies and the means by which wire spacing is maintained on line posts. Being a spacing tool rather than an attaching tool, staples should not be driven tightly against the wire on line posts. Leaving a space between the staple crown and the wire on line posts allows the wire to slide between the staple and the post. This allows for expression of elastic action of the wire and distributes stress loads over the entire length of the wire. Conversely, driving staples tightly against the wire on line posts results in short, independent, more rigid lengths of fence that will stretch or break under stress loads.

DROPPERS

Droppers, or stays, are used to maintain wire spacing between posts and to give visibility to the fence. They also function in distributing stress forces over all of the fence wires. Droppers should be inexpensive, easily attached and strong enough to resist bending or breaking under stress loads.

B A S I C P R I N C I P L E S

POST SPACING

Common practice and belief is that fence posts must be close

together with wire tightly attached to them to make a strong fence. The facts are, however, that with tensioned wire, the reverse is true. When an impact force is applied to a fence wire, the lateral forces acting on the posts will lessen with increasing distance between them (Fig. 2).

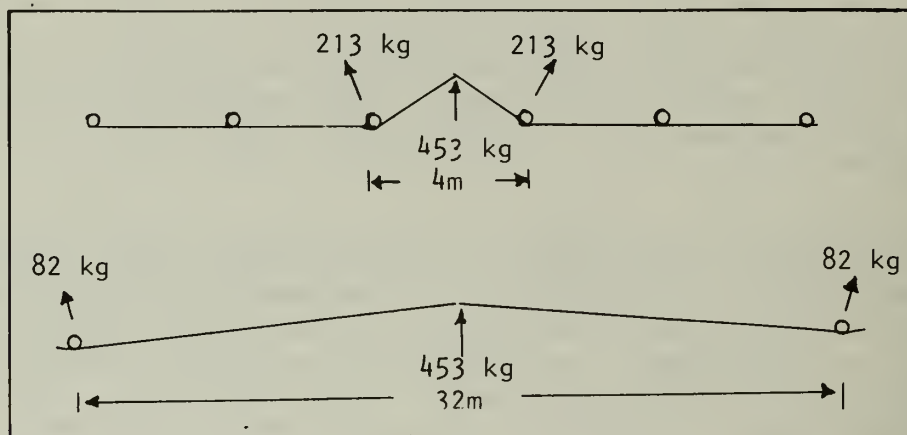


Figure 2. Effect of Post Spacing on Lateral Loads Applied to a Fence.

This means that closely spaced posts must absorb more of the force of an impact on the wires and the chance of post failure, by breaking or overturning, is increased. If the staples holding the wires have been driven tightly against the wire, the problem is compounded. These short spans behave as individual fences and are required to absorb the total stress load applied to them, greatly increasing the chance of failure of both posts and wires.

WIRE PROPERTIES

ELASTICITY. Pre tensioned (straightened) barbed wire and high tensile steel wire elongate at a rate proportional to an applied tension, up to the elastic limit or yield point of the wire. The stress-strain relationship is approximately linear to the yield point which is about eighty percent of the breaking strength of the wire. If a wire is subjected to a tension less than the yield point the wire will return to its original length when the tension is removed. However, if the tension exceeds the yield point the wire will be permanently stretched.

STAPLING. Driving staples tightly against the wire on line posts interferes with the wire's elasticity and reduces the wire's tolerance to impacts. Very little

force is required to deflect such rigid wires and small forces result in the generation of large wire tensions in short spans of fence. However, if the staples are not driven tightly against the wire the deflection due to impact is distributed over a greater length of wire and the elongation per meter of wire is very small. As a result, a minimal increase in wire tension is generated. To illustrate this principle consider:

- i. Post spacings of 6 m;
- ii. Elongation rate of wire of 0.93 mm/m/100 kg;
- iii. Original wire tension of 136 kg;
- iv. Brace assemblies (wire attached tightly) spaced 200 m. apart.

Condition 1. Staples are driven to hold wire tightly to line posts and a force sufficient to deflect a wire 30 cm is applied.

Solving the triangle, the resultant elongation in the wire is then $2(\sqrt{3m^2 + 30cm^2} - 3m) \approx 30$ mm over the 6m wire or 5 mm ($30 \text{ mm} \div 6m$) per each meter of wire. Since wire elongates at 0.93 mm/m for each 100 kg applied, an elongation of 5 mm/m results in an increase in tension of about 538 kg ($5 \text{ mm/m} \div 0.93 \text{ mm/m/100 kg}$). Since the wire was originally tightened to 136 kg tension, this increase will exceed the tensile strength of the wire. If the staples and posts hold, the wire will break. Otherwise, posts will be pulled loose, staples will be pulled out and the wire will be permanently stretched.

Condition 2. Staples are driven to allow wire movement between post and crown of staple and a force sufficient to deflect a wire 30 cm is applied.

Solving this triangle, the resultant elongation in the wire is then $2(\sqrt{3m^2 + 30cm^2} - 3m) \approx 30$ mm spread over 200 meters of wire or 0.15 mm ($30 \text{ mm} \div 200m$) per each meter of wire. Since wire elongates at 0.93 mm/m for each 100 kg of load applied, an elongation of 0.15 mm/m results in about a 16 kg ($0.15 \text{ mm/m} : 0.93 \text{ mm/m/100 kg}$) increase in tension.

This, added to the original tension (136 kg + 16 kg), is well within the elastic limit of the wire. The wire would withhold the force (turn the animal) and return to its original length and tension when the force was removed. There would be no damage to the fence.

Remember, when the staples are driven to hold the wire tightly to line posts, relatively small deflections (small loads) result in relatively large wire tensions and the yield point of wire is more likely to be exceeded. The wire and fence are then more susceptible to permanent damage, sagging and failure.

TEMPERATURE. Another factor affecting wire which should be considered is expansion and contraction with changing temperatures. A 5°C change in temperature results in a 5 kg change in wire tension, independent of length. Thus allowances for temperature must be made when tightening fence wires or a means to readily change wire tension must be incorporated in the fence. Recommended wire tension is 136 kg at 0°C ; 126 kg at 10°C ; 116 kg at 20°C etc.

BRACES.

Brace assemblies should be placed as far apart as the terrain will allow, up to a maximum separation of 400 m. Braces are the anchors for the fence wire so must be as square and as strong as possible.

Brace posts tend to rotate on their axis in shifting to equilibrium when tension is applied and brace components come under compression. Only 25 mm of such movement can reduce tension by half in a 100 m span, thus tension in a 100 m fence tensioned at 45 kg is reduced to 23 kg. However, the same movement (25 mm) in a 200 m fence would only reduce the tension by one quarter from 45 kg to 34 kg.

Test results of the force at failure of several types of brace assemblies (Fig. 3) are given in table 1. Since all double brace assemblies tested were strong enough to withstand forces sufficient to break the fence wires, type 3 was selected as the standard for end and corner braces. This brace is easy to build, will compensate for less exacting workmanship and is aesthetically pleasing. In situations where a single brace is desired, a type 4 would give sufficient strength. Type 4 braces must be built to exacting specifications.

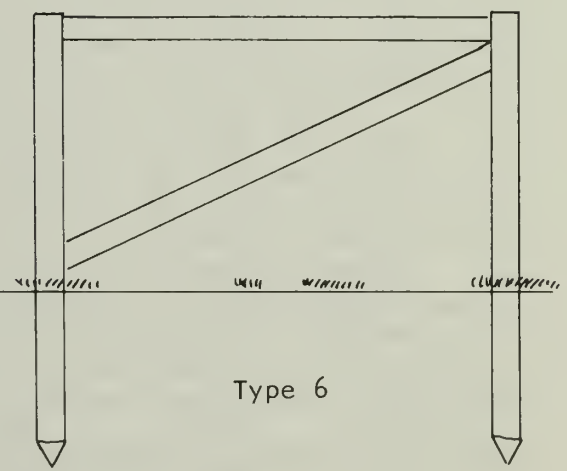
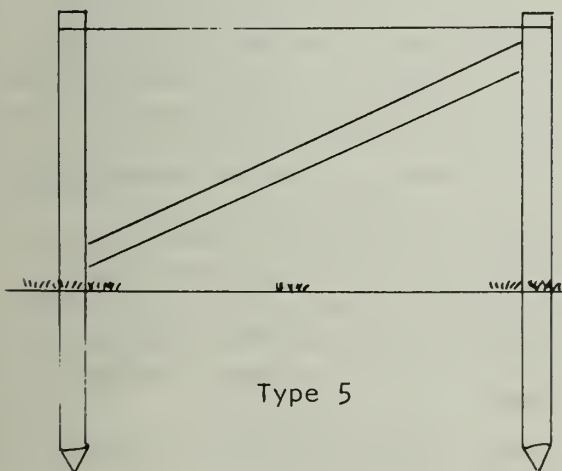
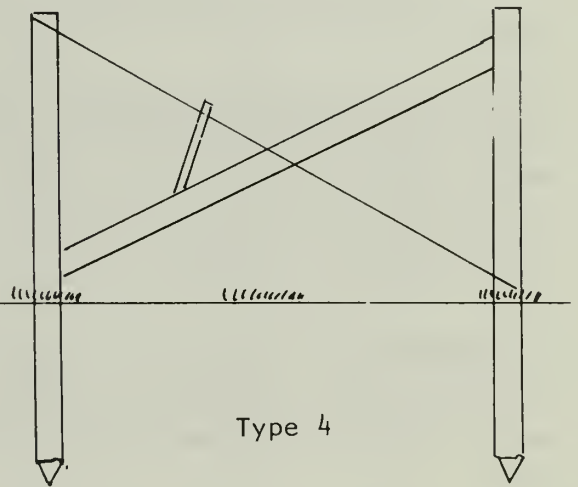
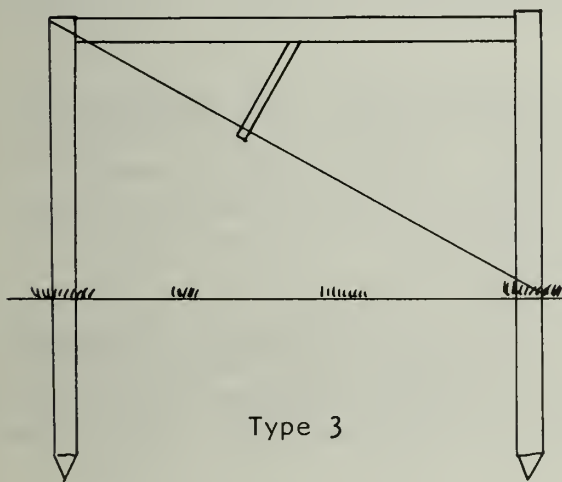
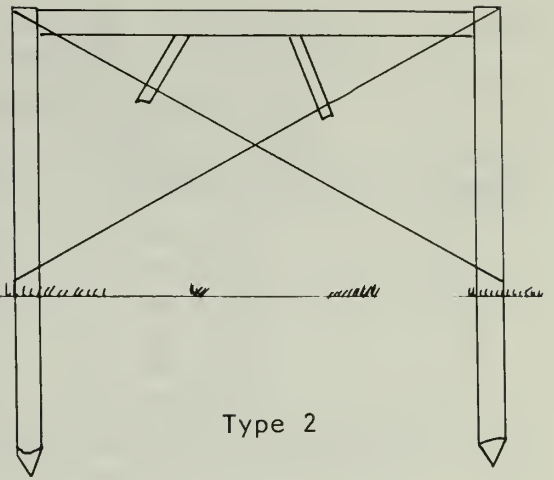
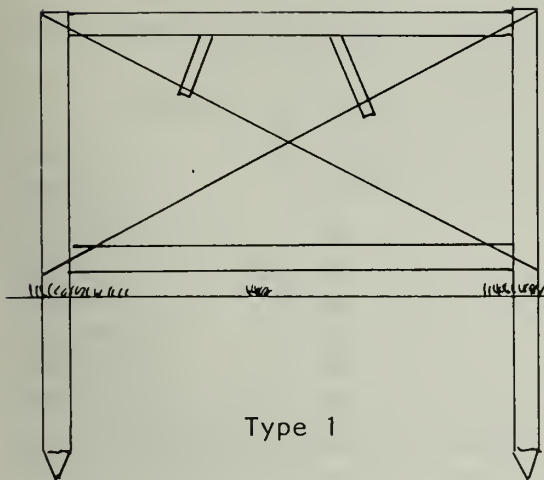


Figure 3. Types of Brace Assemblies Tested.

Table 1. Strength of brace assemblies at failure (215 cm x 127 mm post driven 76 cm)

Brace Type	Single Braces		Double Braces	
	Deflection at 680kg	Load at Failure	Deflection at 680kg	Load at Failure
1	15.2 mm	2721 kg	8.6 mm	1633 kg
2	19.6 mm	2520 kg	12.2 mm	1451 kg
3	29.0 mm	2520 kg	12.4 mm	1315 kg
4	3.3 mm	2721 kg	3.3 mm	2540 kg
5	8.4 mm	1860 kg	3.6 mm	1769 kg
6	4.3 mm	2721 kg	2.3 mm	1451 kg

FENCE MATERIALS

POSTS

The most suitable material for high tension and high tensile fence construction is wood, specifically sharpened round wooden posts that can be driven into the ground and that have been chemically treated to resist rot. Softwood posts, such as pine, absorb chemicals well, are light in weight, fairly strong and inexpensive, and have a long life expectancy.

Pressure treated posts are relatively straight and are sharpened to facilitate driving. Posts vary in diameter from end to end and from post to post. All diameters specified in this bulletin are minimum recommendations and refer to the smallest end of the post.

Posts, treated to resist weather, rot, fire and termites, are available. Proper treating under pressure will result in posts which will last up to 40 years. Posts which have been dipped, soaked, or which have had preservative brushed on them should be avoided. Such posts may be inexpensive, but they are poor value. They will last only a relatively short time before they will need replacement. By themselves, posts used in brace assemblies must be strong enough to withstand the wire tension of the entire fence as well as to absorb impact stresses without failing. By themselves, wires can exert forces on end posts that exceed 1100 kg for a ten wire fence. Line posts must carry part of the weight of the wire and must absorb part of any impact forces acting on the wire. Test results for pressure treated pine posts are given in Fig. 4 and Table 2.

There are several types of treated posts available from reputable manufacturers. A buyer should satisfy himself of the

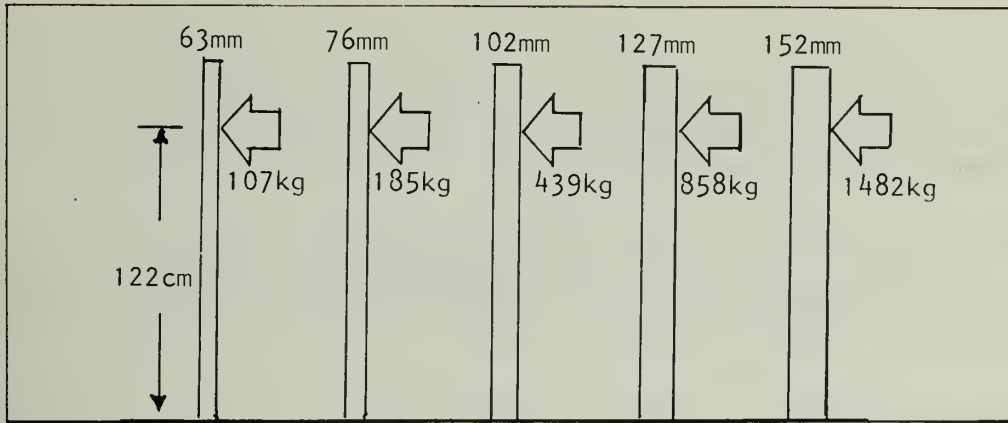


Figure 4. Average Breaking Strengths for Pressure-treated pine posts with loads steadily applied.

Table 2. Lateral loadbearing capacities of driven posts

Size	Soil	Depth Driven (cm)	Kg Force	Failure
102 mm	Soft clay	76	45	overturn ¹
	Medium clay	76	408	overturn
	Stiff clay	76	635	lean
	Very stiff clay	76	680	lean
102 mm	Soft clay	107	84	overturn
	Medium clay	107	590	overturn
	Stiff clay	107	748	lean
	Very stiff clay	107	771	lean
102 mm	Soft clay	122	104	overturn
	Medium clay	122	601	overturn
	Stiff clay	122	771	lean
	Very stiff clay	122	794	lean
127 mm	Soft clay	122	136	overturn
	Medium clay	122	998	overturn
	Stiff clay	122	1474	lean
	Very stiff clay	122	1520	lean
127 mm	Soft clay	122	186	overturn
	Medium clay	122	1451	overturn
	Stiff clay	122	2449	overturn
	Very stiff clay	122	1540	lean

¹ Greater than 130 mm lean.

quality of preservative, and methods of preserving used before purchasing posts. It is too late to return an inferior product after it has been in the ground for a year or two. Recommendations are given below.

Preserving chemicals can cause reactions in people susceptible to allergies. The use of protective full-length clothing, gloves, and eye or face shields is necessary when working with chemically treated posts.

RECOMMENDATIONS

Penta-Treated Posts. Pentachlorophenol is a wood preservative used to treat softwood posts. The dry chemical is mixed with oil and forced into the wood in a pressure chamber. Pentachlorophenol crystals remain in the wood when the pressure is removed. Penta-treated posts should contain a minimum of 4.0 kg of pentachlorophenol per cubic meter of wood, or meet CSA Standard 080.5.

CCA Treated Posts. Chromated copper arsenate dissolved in water is an excellent preservative for wood posts. Evaporation of the water, after pressure treating, leaves the salt, which is poisonous to decay fungi and insects, deposited in the wood. These posts are dry, do not have an oil residue and can be painted. They are a light green colour after treatment. CCA treated posts should contain a minimum of 6.4 kg of chromated copper arsenate per cubic meter of wood or meet CSA Standard 080.5.

Pressure-Creosoted Posts. Creosote is the oldest and most widely used wood preservative. Pressure creosoted posts give excellent protection against moisture, insects, and decay, and are resistant to grounding if the fence is electrified. They can be expected to last an average of 35 years and up to 70+ years under dry conditions. These posts are fire retardant in that they surface char and then self extinguish. Pressure-creosoted posts should contain a minimum of 96.0 kg of creosote per cubic meter of wood or meet CSA Standard 080.5

DROPPERS

On even-contoured terrain, the post spacing of range fences can be 18 m or greater if droppers are installed between the line posts. The number of droppers depends on the type of livestock and the intensity of pressure on the fence. Under range conditions with light to moderate livestock pressure on fences, one dropper every 6 m is adequate. One dropper every 3 m is recommended for moderate to heavy livestock pressure and one dropper is required every 1.5 m for heavy livestock pressure.

Droppers should not bend with normal impacts on fences. They should maintain wire spacings at all times and should have a life expectancy equal to that of the rest of the fence.

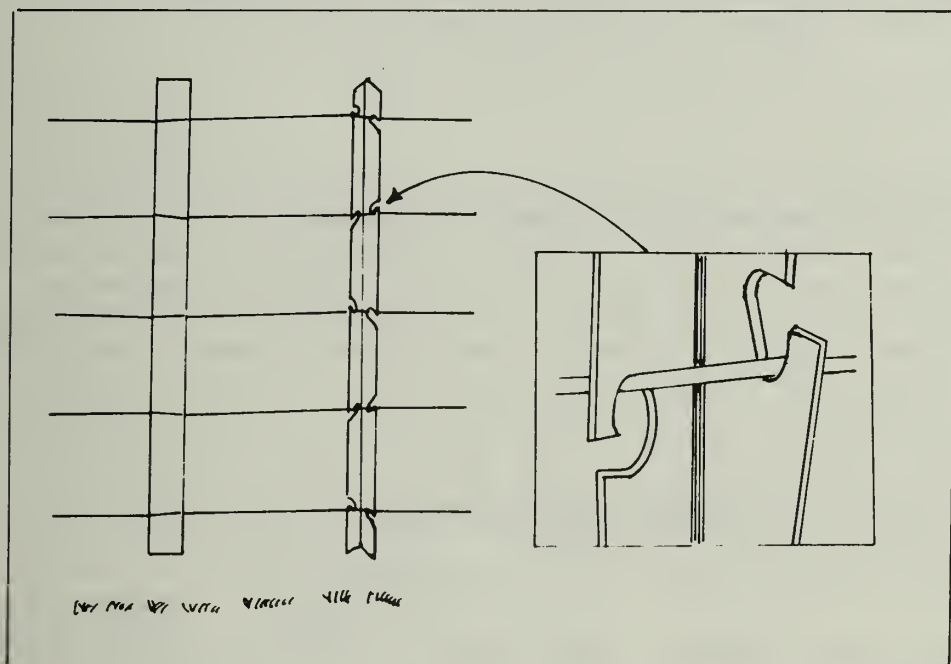


Figure 5. Angle Grooved Wood and Snap on Metal Droppers.

Many types of droppers are available in Canada. For most conditions either wooden or sheet metal droppers are recommended. Wooden droppers should be sufficiently rot resistant to last as long as the fence. Wood droppers are often made from cut saplings in forested areas, from treated 25 x 100 mm

lumber, or from 38 x 38 mm split cedar. Sheet metal droppers are fabricated from 18 gauge galvanized steel. Another popular dropper, which is inexpensive and easy to install, is made from twisted wire. However, these droppers permanently bend under very light loads or impacts. Because of this, twisted wire droppers should be used only on fences subjected to very light livestock pressure.

Since droppers are not driven into the ground, they must be firmly attached to the fence wires. Droppers may be smooth, notched or grooved to accept fence wire and either snap or are wired or stapled onto the fence wires.

If slotted wood or sheet metal droppers, which snap onto the wire, are used, care must be taken to insure that the droppers will not slide along the wire after installation (Fig. 5). This is best prevented by insuring that there is a slight offset in wire grooves during manufacture.

WIRE

All wire for high tension and high tensile fences should be 12½ gauge triple galvanized (Type III) steel wire. To be safe and function properly, barbed wired should have a tensile strength of at least 4900 kilograms per square centimeter. High tensile wire should have a tensile strength of at least 9800 kg/sq.cm. Table 3 shows a comparison between characteristics of barbed and high tensile wire.

Table 3. Wire Specifications

Wire Type	Gauge	Dia mm	Breaking Strength		Elastic Limit	
			Kg	Kg/cm ²	Kg	Kg/cm ²
Barbed	12½	2.54	431	4921	399	4007
High tensile tying	12	2.69	590	10545	499	8928
High tensile fence	12½	2.46	644	12441	485	10179
Max-ten 200 fence*	12½	2.51	823	16576	735	14760

* United States Steel tradename

ADVANTAGES OF HIGH TENSILE WIRE OVER BARBED WIRE ARE:

1. Cheaper than barbed wire (less than half price for equal length).
2. Easier to string out and handle. All of the wires can be strung out and tightened in the same operation since there are no barbs to tangle with other wires or vegetation. This feature alone can save walking 9 km for each 1.6 km of 5 wire fence constructed.
3. Safer for livestock and wildlife, no barbs to damage hide.
4. It behaves elastically along the entire length of wire since there are no barbs to hang up on staples. Thus it tolerates greater shock loads.
5. It does not require prestretching to obtain elastic properties.
6. It has a greater tensile strength than barbed wire of the same gauge.

FASTENERS

STAPLES (Fig. 6); It is recommended that staples not be fully driven into line posts. Thus longer staples are needed. These should be 4.5 centimeters long, corrosion resistant with opposing slash cut points. Galvanized staples have a greater holding power than smooth staples. Staples should number about 60 per 450 grams.

DOWEL PINS, SPIKES. Dowel pins of varying length or spikes, will be needed for constructing brace assemblies. Both should be corrosion resistant. Spiral spikes will hold better than smooth or coated spikes, but are difficult to remove.

END POST FASTENERS. Wire may be tied off at end, corner, and gate posts by using various knots. Tests have shown that these reduce wire strength by 40% and are the weakest part of the fence. They are presented here as an alternative to mechanical fasteners.

KNOTS

Barbed Wire. It is traditional to tightly staple barbed wire to brace and end posts, and to anchor the wire by double wrapping around the end post and fastening along the line wire by tightly twisting around the line wire. This works well if staples are driven snugly against the wire, but not so tightly that the wire is weakened or damaged. In high tension fence, the staples on end and brace posts should be driven adjacent to the barbs, where possible, to prevent wire slippage in the direction of wire pull when the wire puller is released after tightening.

High Tensile Wire. This wire may also be tied off at end or brace posts with a special knot (Fig. 7) after stapling to brace and end posts. To tie this knot, allow about 76 cm of wire beyond the end post and wrap this around the post from the livestock pressure side. Passing the free end under the line wire, loop it back over the top of the line wire allowing several inches of clearance from the post. Pass the free end between the loop wire and the post, and pull, snugging the loop tightly against the post. Secure the free end to the line wire with pigtail wraps starting over the line wire.

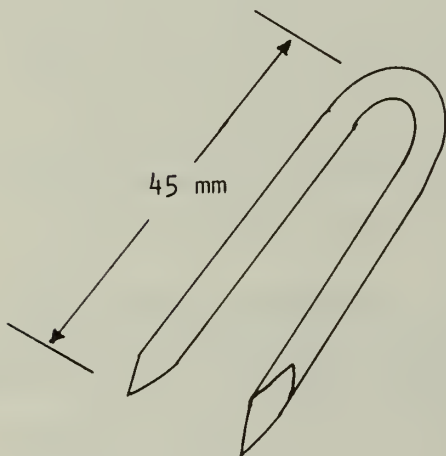


Figure 6. Staple

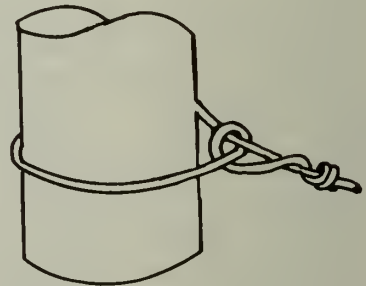


Figure 7. Knot for tying off High Tensile Wire

COMPRESSION SLEEVES. These may be used to tie wire off at end posts and braces (Fig. 8). Tests show that these

fasteners will retain 100% of the strength of the wire when properly installed. To use compression sleeves, leave about 60 cm of wire beyond the post. Before stapling, thread two or three oval sleeves onto the wire. Slide these back beyond the post. Wrap the wire around the post from the livestock pressure side and thread the free end through the compression sleeves. Position the sleeves a few inches from the post and double crimp each sleeve with a swager (see Fig. 14. Page 20).

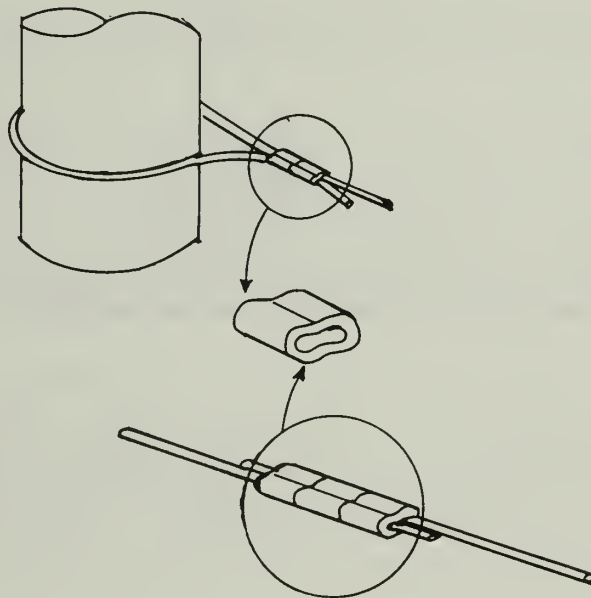


Figure 8. Oval Compression Sleeves.

Wirevise.* Another method of securing high tensile wire to end posts is with a Wirevise (Fig. 9). A 9.5 mm hole is drilled through the end posts, at the desired wire height, at a slight angle away from the livestock side of the fence. Thread the wire through the hole and the wirevise. Slide the wirevise forward and embed it into the hole. The wirevise will clinch the wire when reverse tension is applied and will be flush with the post. Cut surplus wire off flush with the fitting. This fastener

is effective to 100% of the strength of the wire.

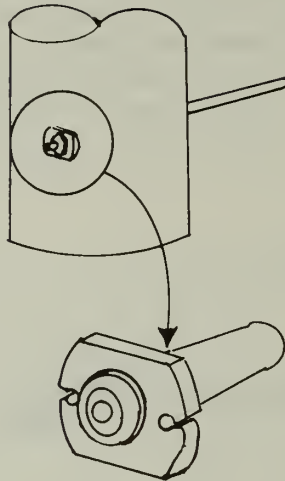


Figure 9. Reliable Wirevise for High Tensile Wire.

WIRE SPLICING. Wire may be spliced with knots, which are generally effective to 60% of the strength of the wire, or with mechanical fasteners. Mechanical fasteners are effective to 100% of the wire strength when installed properly.

KNOTS

Barbed Wire. The most common method of splicing barbed wire is to form about an 8 cm loop by bending one end of the wire back along itself and securing by wrapping tightly around the line wire. The free end of the joining wire is threaded through the loop and bent back along itself to form a similar loop secured by wrapping tightly around the line wire.

High Tensile Wire. The knot most often used to splice this wire forms a figure eight (Fig. 10). To tie this knot, overlap about 20 centimeters of the ends of the wires to be spliced, and bend a loop in the end of each around the other wire so that the loops are in opposite directions. Bring the end of the wire in each loop under itself so that the ends are pointing in opposite directions. Pull the loops tightly together. After the

wire is tightened, remove excess wire.

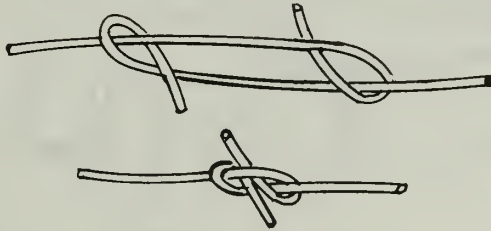


Figure 10. Figure Eight Knot for Splicing High Tensile Wire

COMPRESSION SLEEVES. These can be used to splice wire as well as to tie off wire at end posts (see Fig. 8). Thread the ends of both wires through the sleeves. Double crimp each sleeve with a swager to complete the splice. Compression sleeves are effective to 100% of the breaking strength of the wire.

WIRELINK.* A wirelink is available which will butt-splice high tensile wire by simply inserting both wires as far as possible into the ends of the fixture (Fig. 11). Pulling in the opposite direction locks the wire, giving 100% of the breaking strength of the wire.



Figure 11. "Reliable" Wirelink for High Tensile Wire

IN-LINE STRAINERS AND TENSION SPRINGS

Other items available for high tensile fencing include adjustable in-line wire strainers with removable handles and in-line tension indicator springs (Fig. 12). Both of these are permanent in-line fixtures in each span of fence. Unless other means are used to tension the fence wires, these should be. One ratcheted wire strainer per wire will allow a manager to tighten or relax the wire in relation to temperature. Their use provides an easy and efficient way of retaining correct tension in line wires. They also facilitate quick repairs and retightening should the fence break.

*Reliable Electric Company Trademark

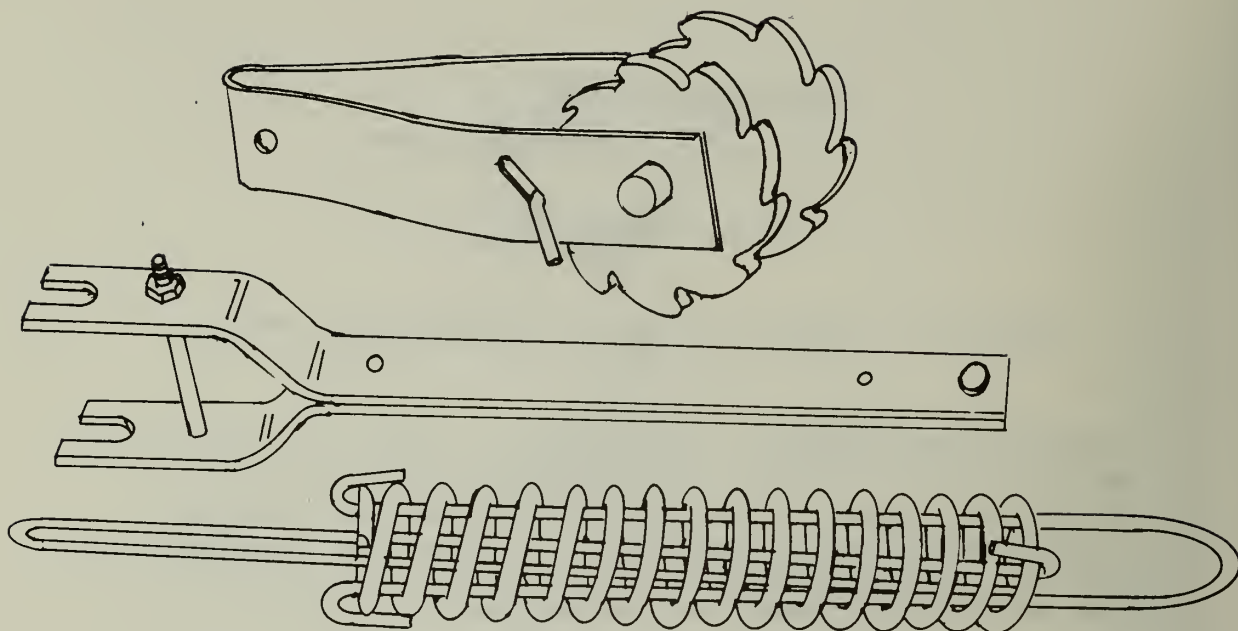


Figure 12. In-line wire strainer, handle, and tension indicator spring.

At least one tension indicator spring permanently installed on one wire of each span of fence is required. The remaining wires of each span of fence are tensioned by finger tuning to the wire tensioned with the spring. With practice this method is remarkably accurate.

TOOLS

All forms of construction require an assortment of tools designed to do specific jobs. Few things are more frustrating than not having a needed tool or having a poorly designed tool that does not work properly. Tools required in erecting high tension fences are as follows:

SPECIAL TOOLS (Fig. 13)

- a. Wire benders - hand fabricated of metal to work with high tensile wire. A small pair of vice grip pliers works well too.
- b. Post hole auger.

c1 & Wire sheaves - these are constructed of 13 mm
c2 plywood and consist of aluminum rollers, either adjustable or fixed, and a means of temporarily attaching to line posts. They function in spacing line wires parallel to the ground when placing tension on a fence. For high tensile fences, spikes can replace the rollers or the wire can be pre-stapled since there are no barbs to hang up. A number of these will be needed depending on the terrain.

d. Hand swagers - crimping pliers for compression sleeves. These are available commercially or can be fabricated from a pair of 450 mm bolt cutters with an 8 mm capacity. Drill a 9.5 mm hole to crimp a 3.97 mm oval sleeve that accepts barbed wire. Drill a 6.35 mm hole to crimp a 2.38 mm oval sleeve that accepts high tensile smooth wire.

e. Wire pullers - these should have smooth jaws to protect the galvanized surface if working with high tensile wire.

f. Fencing pliers.

g. Two man post pounder.

h1 & Tensionmeters - h1 is made by installing a
h2 compression spring inside a pipe. A graduated 8 or 9.5 mm plunger is attached to pass through the spring so a pull on both ends compresses the spring. One spring that works well is part number D4804 for a Morris Rod Weeder drill. This spring compresses 15 mm for every 45.4 kg load applied up to 272 kg. Other springs will work equally as well if calibrated.

h2 consists of a straight piece of 20 mm x 50 mm board 107 cm long. Drive two nails on a straight line 102 cm apart at the ends of the board. At the middle of the board drive a third nail 13 mm below the line joining the end nails. Tension is measured by pulling the fence line wire to just touch the centre nail and multiplying the scale reading by 20.

i. Wire reel.

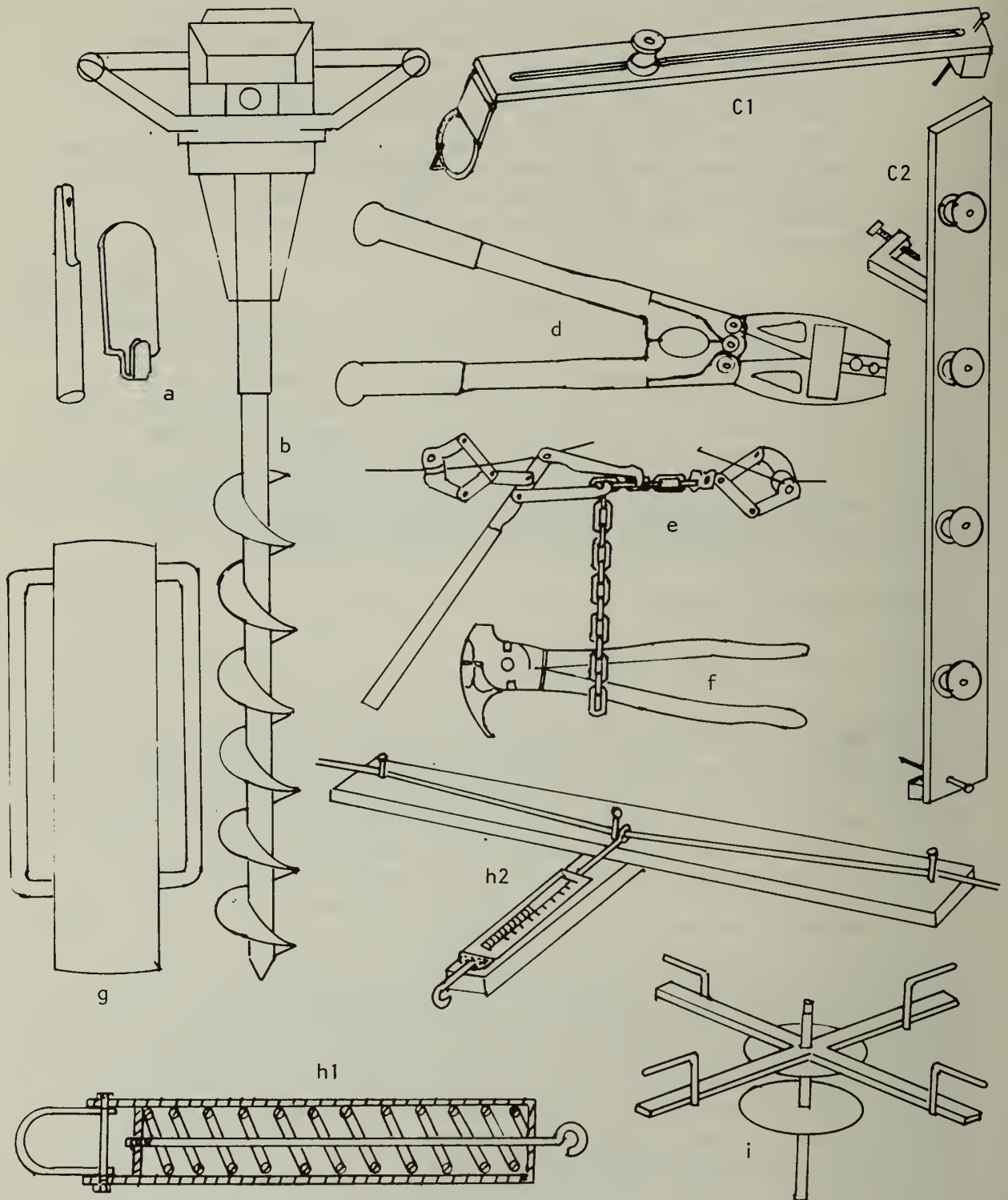
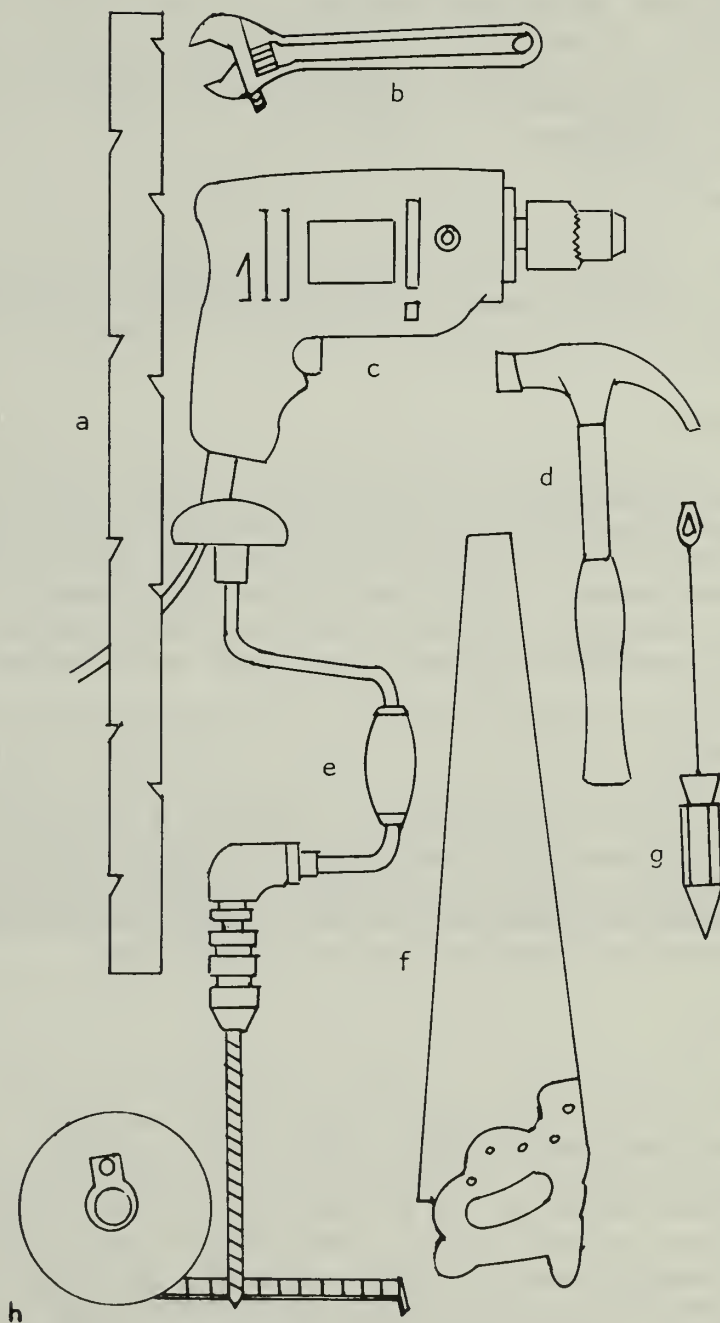


Figure 13. Special Fencing Tools

COMMON TOOLS (Fig. 14).

- a. Notched marking stick.
- b. 25 cm crescent wrench.
- c. 12.7 mm electric drill.
- d. Claw hammer.
- e. Hand brace and 9.5 mm x 200 mm bit.
- f. Saw.
- g. Plumb bob
- h. 18 meter chain or tape.



P L A N N I N G T H E F E N C E

BOUNDARIES

Whether your fence will follow property lines, terrain contours, or is designed to facilitate cattle movement on your range, you

must establish boundaries. It is often advantageous to have a surveyor determine property bounds before perimeter fences are built. Then if it is desirable to fence on contours to facilitate cattle movement, an agreement can be struck between good neighbours. Remember, however, that the fence may outlast the neighbour.

LAWS

Check local laws to be certain that the fence you are planning will legally meet your specifications and requirements. Your district agriculturist should be able to provide this information.

HAZARDS

Locate hazards or constraints such as bogs, embankments, flooding, deep drifting, highways, railways, mining, recreation areas, etc. It may be necessary to provide special fencing for these areas. It is always a requirement to check with electrical, telephone, water, gas and sewer authorities regarding possible buried lines and for fencing of easements that may exist.

TERRAIN

Check your topography. Fencing in hilly areas and on curves can present special problems which require special construction techniques and materials. Remember that all wires on any fence should be parallel to the ground, which may require some grading or special fence assemblies.

SOILS

Check your soil. Soils can greatly effect the materials and methods of fencing. Generally, however, whether your soil is soft, medium or hard clay, or is sandy, the best method of setting posts is by driving. Tests have shown that the force required to pull a driven post can be ten times greater than that of a post set by digging, backfilling and tamping. Driving posts in hard soils may require small pre-augered holes in which to drive the post, but it may be worth the extra effort. Similarly, some situations may require a deadman be anchored in the bottom of a hole to hold a post in place.

Table 2 (page 9) shows the effect of post diameter and depth of placement on the treated wood posts.

PERFORMANCE

Consider what you expect of the fence. For example, a fence that is well designed for cattle on the open range may be ineffective in containing calves or yearlings in a confined pasture situation. Usually, perimeter or boundary fences must be more secure and versatile than division fences. Perimeter fences must often contain more than one kind of livestock, protect crops, or turn away wildlife. Your plans, and a knowledge of animal behaviour, will be helpful in designing your fence.

LOCATION

Fences should be designed so they are more than dividing barriers. Fences should also be an aid in livestock management allowing for efficient movement of livestock, easy access to water, increased forage utilization, ease of movement of livestock, and ease of movement of farm machinery.

PREPLAN

Sketch your layout and itemize materials. This should include fence dimensions, corners, angles at change of direction, gate locations and widths, rises and dips, etc. that can influence materials or construction. From this sketch it is possible to determine the number of posts, amount of wire, staples, fasteners and other hardware that will be required. Further, the costs involved can be estimated more accurately before the job is started

S P E C I F I C T I O N S

High tension fences are versatile and it is possible to select a design for practically any requirement or set of requirements. These fences can be easily modified by adding or removing wires. Smooth wire fences can also be electrified. Many fences are overdesigned for their intended purpose. While these fences may produce additional safety, the extra materials and labour involved may nullify any benefit gained. Following are specifications for several fence designs.

FOUR WIRE BARBED WIRE RANGE FENCES

These designs are adequate for cattle on range where there is not unusual crowding to force calves against the fence. They allow wildlife to move freely by crawling under, or jumping the

fence. The 101 cm fence is used in areas of high deer traffic. Cattle, particularly bulls, will have a tendency to attempt to jump low fences.

Height of top wire	101 cm or 116 cm.
Wire spacing from ground up: (116 cm fence)	38 cm, 25 cm, 25 cm, 28 cm.
Wire spacing from ground up: (101 cm fence)	38 cm, 20 cm, 20 cm, 23 cm.
End post length & diameter:	244 cm x 152 mm, driven 122 cm.
Brace post length & diameter:	244 cm x 101 mm, driven 122 cm.
Top brace:	244 cm x 101 mm
Line posts:	200 cm x 76 mm driven 76 cm.
Post spacings;	18.5 m
Droppers:	metal snap on or wood 38 mm x 28 mm, 3 m spacing.
Wire tension:	Tension barbed wire to 270 kg to remove kinks, then relax and fasten at 136 kg at 0°C or equivalent, to gain elasticity.

FIVE WIRE RANGE FENCE

The five wire high tensile wire fence is a range fence replacing the four wire barbed wire fence. The five wire barbed wire fence is a fence for medium to heavy livestock pressure.

Height of top wire	114 cm
Wire spacing from ground up:	barbed wire - 31 cm, 20 cm, 20 cm, 20 cm, 23 cm. high tensile- 40 cm, 18 cm, 18 cm, 18 cm, 20 cm.
End post length & diameter:	244 cm x 152 mm, driven 122 cm.
Brace post length & dia:	244 cm x 101 mm, driven 122 cm.
Top brace:	244 cm x 76 mm, driven 76 cm.
Post spacings:	up to 18.5 m

Droppers - 38 mm x 38 mm, spaced at 4.6 m for
galvanized metal snap light grazing pressure, 3 m for
on or wood: moderate to heavy grazing pressure.

Wire tension: Tension barbed wire to 270 kg to
remove kinks, then relax and
fasten at 137 kg at 0°C or equiva-
lent to gain elasticity. Tension
high tensile wire to 136 kg at
0°C or equivalent.

SIX WIRE HIGH TENSILE LIVESTOCK FENCE

This fence replaces the four or five wire barbed wire fence. It is designed primarily for moderate to heavy grazing pressure by large animals.

Height of top wire: 116 cm
Wire spacing from
ground up: 33 cm, 15 cm, 15 cm, 15 cm, 18 cm
20 cm.
End post length & dia: 244 cm x 152 mm, driven 122 cm.
Brace post length & dia: 244 cm x 101 mm, driven 122 cm.
Top brace: 244 cm x 101 mm
Line posts (minimum): 200 cm x 76 mm, driven 76 cm.
Post spacings: up to 18.5 m
Droppers: galvanized metal snap on or wood
4.6 m spacing for light grazing
pressure, 3 m spacing for moder-
ate to heavy grazing pressure.
Wire tension: 136 kg at 0°C or equivalent.

EIGHT WIRE HIGH TENSILE LIVESTOCK FENCE

This fence will contain both small and large animals on range and will discourage some wildlife and dogs.

Height of top wire: 117 cm
Wire spacing from
ground up: 10 cm, 13 cm, 13 cm, 13 cm, 15 cm,
15 cm, 18 cm, 20 cm.

End post length & diameter:	244 cm x 152 mm, driven 122 cm.
Brace post length & dia:	244 cm x 101 mm, driven 122 cm
Top brace	244 cm x 101 mm
Line posts:	200 cm x 76 mm, driven 76 cm
Post spacings:	up to 18.5 m
Droppers:	galvanized steel snap on or wood 4.6 m spacing for light grazing, 3 m spacing for moderate grazing, 1.5 m spacing for heavy grazing pressure.
Tension:	136 kg per wire at 0°C or equivalent.

TEN WIRE HIGH TENSILE LIVESTOCK FENCE

This fence will contain most kinds of livestock, turns away many small domestic or wild animals and may be used to replace woven wire. It is a deterrent to carnivores, especially if the second, fourth and top wires are electrified.

Height of top wire:	118 cm
Wire spacing from ground up:	10 cm, 10 cm, 10 cm, 10 cm, 13 cm, 13 cm, 13 cm, 13cm, 13 cm, 13 cm.
End post length & diameter:	244 cm x 152 mm, driven 122 cm.
Brace post length & diameter:	244 cm x 101 mm, driven 122 cm.
Top brace:	244 cm x 101 mm
Line posts:	200 cm x 76 mm, driven 76 cm.
Post spacings:	up to 18.5 m
Droppers:	galvanized steel snap on or wood, 4.5 m spacing for light pressure, 3 m spacing for moderate live- stock pressure, 1.5 m spacing for heavy livestock pressure. (Do not use metal droppers on electri- fied fence).
Minimum wire tension:	136 kg per wire at 0°C or equivalent.

TEN WIRE HIGH TENSILE CATTLE FEEDLOT FENCE

This design differs from other high tensile designs because of the increased livestock pressure. In this design, posts are either drilled for wire passage or are staggered on alternate sides of the wire if livestock pressure will be on both sides of the fence.

Height of top of wire:	133 cm.
Wire spacing from ground up:	25 cm, 10 cm, 10 cm, 10 cm, 13 cm, 13 cm, 13 cm, 13 cm 13 cm.
Gate post length & diameter:	244 cm x 152 mm driven 107 cm.
End post length & diameter:	244 cm x 152 mm driven 107 cm.
Brace post:	244 cm x 127 mm, driven 107 cm
Top braces:	244 cm x 101 mm
Line posts:	244 cm x 101 mm, driven 107 cm
Post spacings:	3 m centers
Wire tension:	136 kg at 0°C or equivalent.
Staples:	45 mm galvanized, slash points (not needed if posts are drilled).
Tension devices:	One in-line wire strainer per wire.
Wire splices:	Three crimped sleeves or Wirelinks.
Tension:	136 kg per wire at 0°C or equivalent.

TWELVE WIRE HIGH TENSILE HORSE FENCE

This fence will secure full grown horses and foals, while discouraging small animals. The top and bottom wires can be electrified to discourage pawing and reaching over the fence.

On high fences it may be necessary to drive posts which are too long to be driven by a hydraulic ram. In these instances, the post may be hand planted by augering and backfilling to a depth that will allow driving with the ram. The post can then be driven to the specified depth.

Height of top wire:	146 cm
Wire spacing from ground up:	10 cm, 10 cm, 10 cm, 10 cm, 13 cm, 13 cm, 13 cm, 13 cm, 13 cm, 13 cm, 15 cm.
Gate post length & diameter:	274 cm x 152 mm driven 122 cm.
End post length & diameter:	174 cm x 152 mm driven 122 cm.
Brace post length & diameter:	274 cm x 127 mm driven 122 cm.
Top braces:	274 cm x 101 mm.
Line posts:	244 cm x 101 mm driven 91 cm.
Post spacings:	4.3 m centers
Wire tension:	136 kg at 0°C or equivalent
Staples:	45 mm galvanized, slash points
Wire splices:	Three crimped sleeves, Wirelinks.

L A Y I N G O U T

LEVEL TERRAIN:

Locate survey pins or stakes at ends of line and stand sighting poles a few cm beyond where the beginning and end of the fence will be. Place one or more intermediate poles and align all poles by sighting over the starting pole to the end pole (Fig. 15).

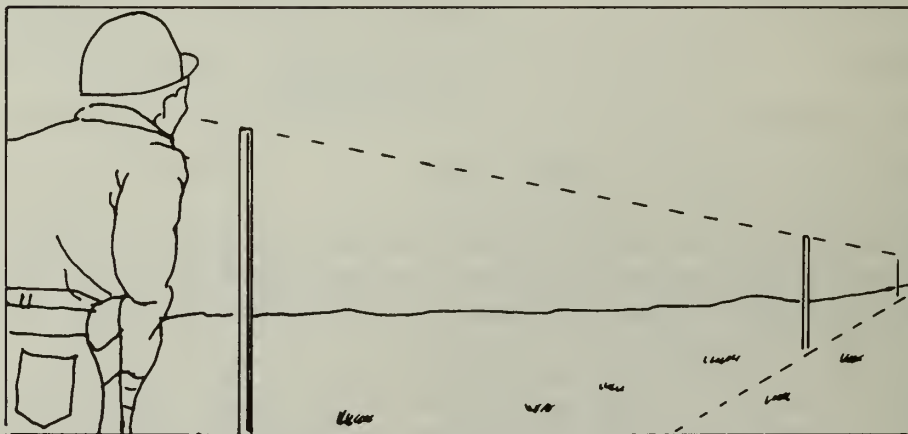


Figure 15. Sighting a Fenceline on Level Terrain

UNEVEN TERRAIN

While rises or dips are in the sighting line, special techniques are involved. For a rise, set two sighting poles about three meters apart at the top of the rise, so that both can be seen from either end of the fence (Fig. 16). When crossing a dip, place two poles and align these by sighting from the highest point on both sides of the dip (Fig. 17).

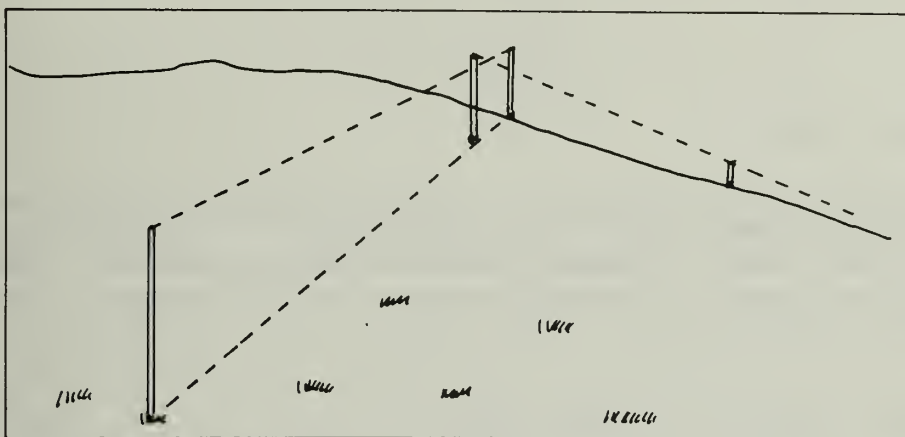


Figure 16. Sighting a Fenceline over Rises

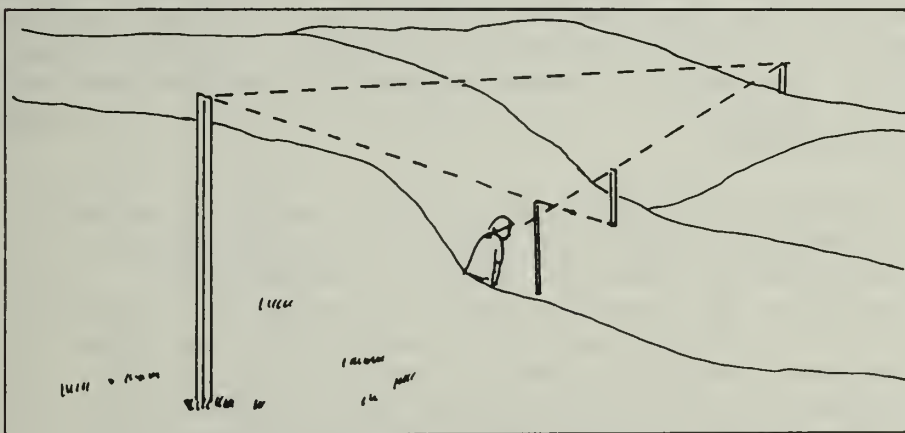


Figure 17. Sighting a Fenceline through Dips

CURVES

It is possible to run high tension wires around curves and corners without constructing brace assemblies. There are, however, certain details and extra care that must be taken. The exact location of posts must be measured and larger sized posts will often be needed. Posts need to be driven deeper

at a 10 cm lean off vertical toward the outside of the curve to allow for movement when tension is placed on the wires. On sharp curves, post spacings will be reduced and all wires will have to be stapled on the outside of all posts in curves.

NOTE: See page 34 under "Construction" for directions on rounding corners.

C O N S T R U C T I O N

CLEARING THE LINE

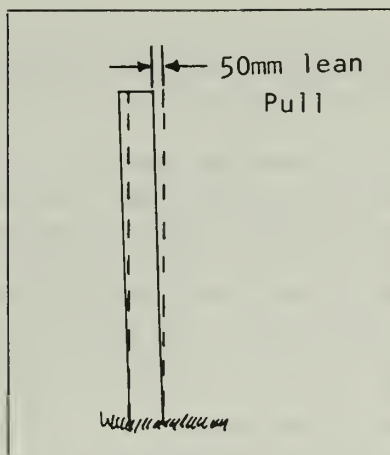
Remove all obstacles that will interfere with fence construction, including small brush and tall grass. If possible, level the fence line. These practices will greatly reduce problems with construction and result in a straighter, easier to maintain, fence.

PLACING END, CORNER AND GATE POSTS

Each section of high tension fence begins and ends at an end post, brace post or gate post. Thus the location and placement of these posts are the most important factor in how your fence turns out. They provide the anchors for the fence and are the first members of brace assemblies which must withstand the tension of the wire. The procedure for setting these posts is as follows:

1. Select a straight 244 cm long post of proper diameter. Mark the exact location where it is to be placed and auger a pilot hole smaller in diameter than the post to a 90 cm depth. (This should be augered so the top of the post will lean 50 mm off vertical opposite the direction of pull of the line wires (Fig. 18). Posts can be driven in some soils without preaugering pilot holes.
2. Drive the post to a depth of 122 cm. Some soils may be particularly loose (bogs, etc.) in which case posts can often be strengthened by placing deadman anchors.

Figure 18. Proper placement of end posts



3. Proceed as above until all end posts are driven.

NOTE: Deadman anchor - Fig. 19 shows a deadman anchor which lessens excessive twisting of an end post. It is constructed from a short piece (30 cm) of 10 cm x 10 cm treated post. Cut one end of this on a 45° angle and fasten a cable (made from twisting wire together) securely to it, about 10 cm back from the diagonal end. Enlarge one side of the bottom of the augered hole, jam the anchor in and pull it taut, forcing the anchor to a position parallel to the soil surface. Drive the post

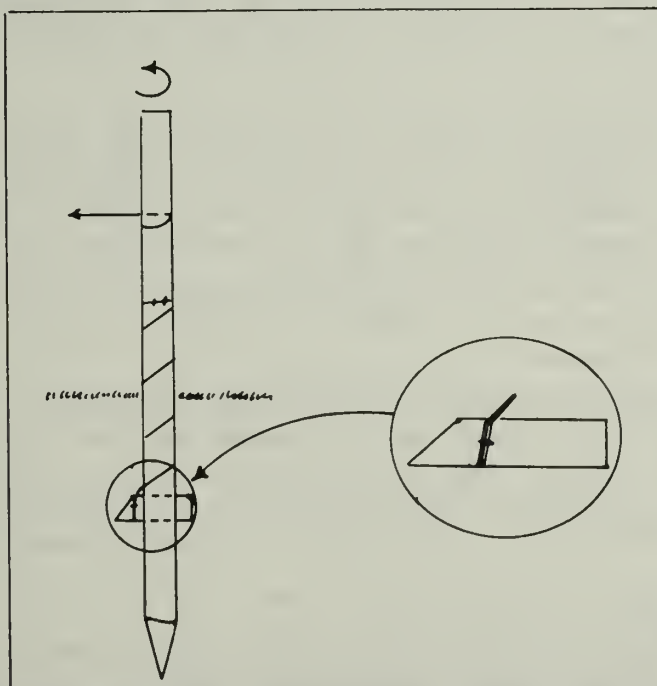


Figure 19. Deadman anchor to prevent excessive twisting of end post

past the anchor and attach the cable to the post in the same direction as any twist that will be placed on the post by the line wires.

It may be necessary to drive posts that are too long to fit under the ram of a post pounder. In these situations, a hole is augered and the post is set by backfilling and tamping to depth such that the post can be driven to the full specified depth by the post pounder.

STRINGING THE GUIDE WIRE

Proper stringing of the guide wire is the key to a straight fence and a fence which has all wires parallel to the soil surface.

Level Terrain

1. Anchoring: Either anchor the wire reel (Fig. 14) or tie off the free end of the wire on the end post at the desired height for the bottom wire. If wire is tied off, a portable reel for paying out wire must be used.
2. Pay out the wire, using the wire reel to avoid kinking the wire, in a straight line to the far end post. Maintain enough tension to prevent loops or recoils of slack wire.
3. Proceed about 90 cm past the end post, attach a wire puller to the free end of the wire and pull it up until taut (about 45 kg tension). NOTE: it is desirable that wire pullers have smooth jaws to prevent damaging galvanization of the wire.
4. Make sure the wire is straight between the posts. Whip the wire up and down or add more tension to accomplish this.
5. Wrap the wire from the livestock pressure side and secure the wire back onto itself at the premarked height of the bottom wire. Temporarily tie off with either an end post tie off knot, a crimped sleeve or with a Wirevise. (See page 13 on end post fastening).

Uneven Terrain

1. Locate the guide wire by either using the sighting poles or by driving permanent posts at the top of rises. If permanent posts are used, care must be

taken in post location (use sighting poles) and in the size of post used in relation to its ultimate function as part of the finished fence.

2. Pay out the wire on the livestock pressure side of the fenceline. Attach a wire puller to the wire and tighten the wire to 45 kg. If permanent posts have been driven, wire sheaves (Fig. 13, page 20) can be used to guide the wire. If the sighting poles are used, care must be taken in relation to the terrain. In the case of high points, the wire will be resting on the ground, but it will be bridging the dips.
3. If wire is on the ground, raise and whip it up and down at the highest point on each rise to get it straight and touching the sighting poles. Mark locations for driving rise posts. NOTE: When driving posts, insure that they are 13 mm off the guide wire. This maintains a straight fence.
4. Drive rise posts, attach wire sheaves or staple smooth wire at desired height for bottom wire. (See section on stapling, page 47).
5. Near the sighting poles in each dip, mark the locations for dip posts. This may be done by using a plumb bob (Fig. 20) if you can reach the guide wire, or by sighting using the sighting poles (Fig. 17).

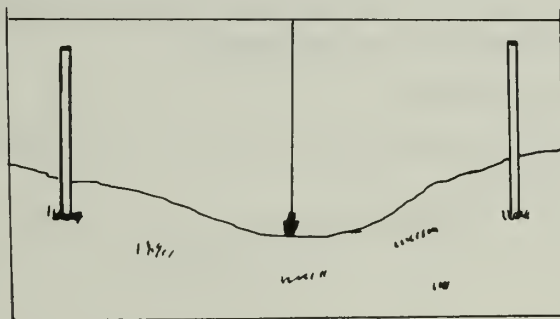


Figure 20. Use of plumb bob for locating post position in dips

6. Drive a 244 cm post to a depth of 122 cm at the location of each dip post.
7. Reduce the tension on the guide wire sufficient to pull it down to the bottom wire height on the dip posts. Wire sheaves or stapling smooth wire can be used to guide the wire. Retighten the wire to 45 kg. NOTE: An alternate method of handling large dips is to allow

the line fence to bridge the dip permanently (Fig. 21). This practice does not necessitate lowering the guide wire into the dip as discussed above, nor does it require longer dip posts. A short span of fence in the dip is fastened to the fence line posts proper but is not tightened to 136 kg tension.

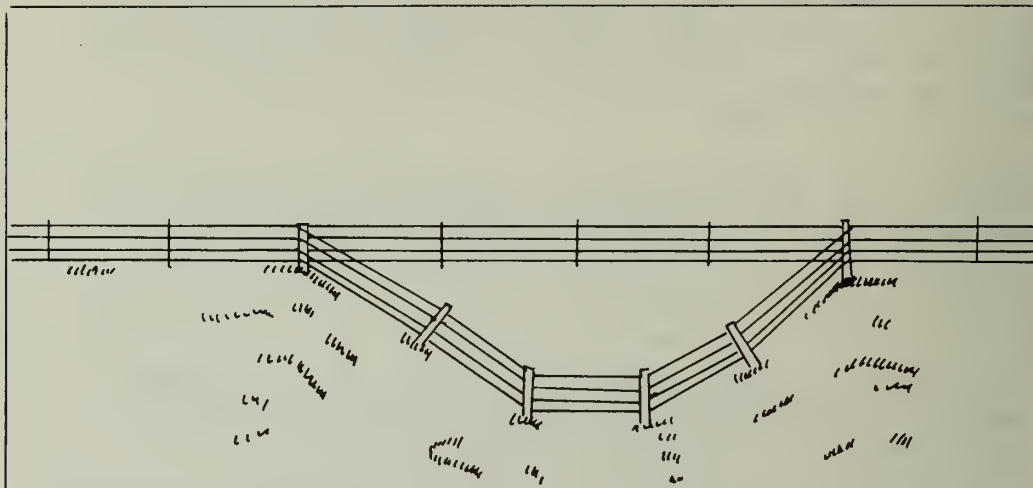


Figure 21. Bridging a Narrow Gully with High Tension Fence

Curves

Line posts in curves should be set before stringing the guide wire using the following techniques:

Shallow - one post curves

1. For change of direction less than 20 degrees (Fig. 22).

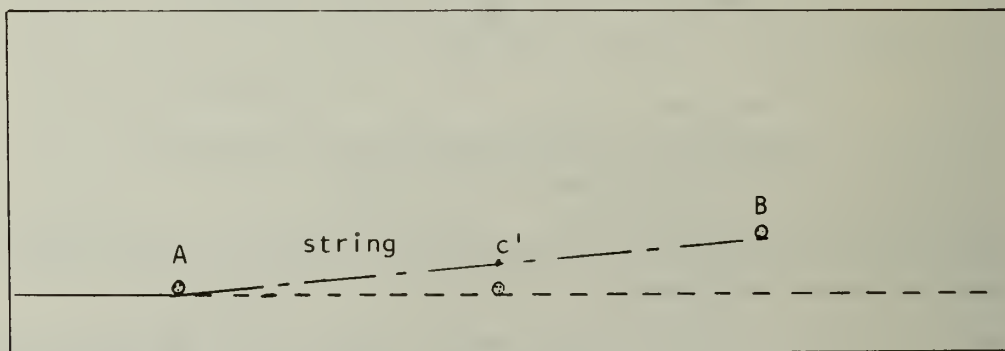


Figure 22. Rounding a Shallow One Post Curve

2. Set stakes on the fence line at the beginning and end of the curve.

3. Stretch string between these two stakes, A and B.
4. Mark the mid point (C') and measure the perpendicular distance to what would be the fence line (C) had it continued in a straight line from stake A.
- 5a. If the distance in '4' above is less than 61 cm, drive a 244 cm x 100 mm post 122 cm deep at the point (C) of intersection with the original fence line.
- b. If the distance in '4' is from 61 cm to 122 cm, drive a 244 cm x 127 mm post at the point of intersection.
- c. If the distance in '4' is greater than 122 cm but not more than 178 cm, drive a 244 cm x 152 mm post at the point of intersection.

Note: The post should be driven at a slant of 10 cm off perpendicular toward the outside of the curve. On fences with less than seven wires, the diameter of posts can be reduced by 25 mm.

Rounding a long gradual curve

This is a continuation of the one post shallow curve technique. The position of each post is determined from the previously set curve post driven 10 cm off the perpendicular to allow for movement when the wires are tensioned. Posts will be at A, C, B, D, etc.

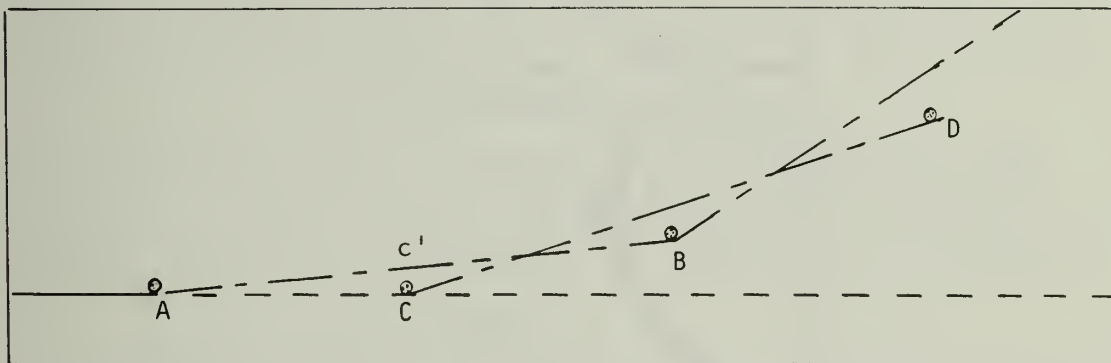


Figure 23. Rounding a Long Gradual Corner or Curve

Rounding a sharp corner or curve (Fig. 24).

Rounding a sharp corner is similar to rounding a shallow corner or curve, but all posts are 244 cm x 152 mm with a 101 mm lean toward the outside. The post spacing is reduced to fit the curve radius. However, posts should not be set less than 122 cm apart to maintain soil stability.

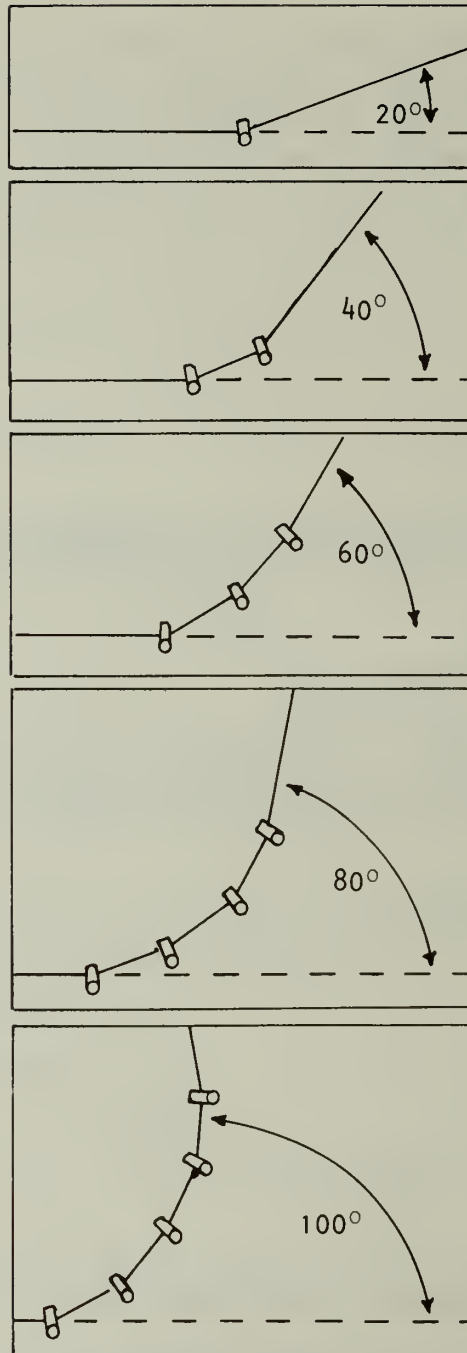


Figure 24. Rounding a Sharp Corner or Curve

NOTE: Use caution when tensioning wire around curves to ensure wire (especially barbed wire) does not hang up on the post.

BRACE ASSEMBLIES

Braces should be constructed at corners, ends of fences, at gates, and in the fence line at appreciable changes in slope of the terrain.

Braces generally should not be spaced more than 400 m apart.

All posts in brace assemblies should be at least 244 cm x 123 mm and should be driven at least 122 cm deep.

All diagonal wires used on braces should be at least 12½ gauge and double or triple wrapped to prevent breakage.

All joints should be carefully constructed using either dowel pins or spikes as fasteners. Dowel pins should be corrosion resistant and spikes should be at least 89 mm longer than the post diameter.

Line wires are tightened and fastened securely to the end post of the brace so the pull is through the brace, then fastened snugly to the first and second braceposts.

BASIC CONSTRUCTION. Shown here are construction techniques for type 3 (page 7) braces. These are easiest to build (less exacting), and are sufficiently strong for all fences, of 12 or fewer wires, described in this bulletin. Double brace assemblies should be used with fences of 7 or more wires and for corner assemblies. Double braces should also be used in cases where smaller posts are used, when posts are not driven a full 122 cm, or in loose or boggy soils.

Figures 25 through 33 show various brace assemblies. Note: Inside brace assemblies, as shown in figures 30, 31 and 32, are subject to cattle rubbing on them in areas of moderate to high cattle pressure. This should be considered in construction of these braces.

Figures 25 to 32 on following pages...

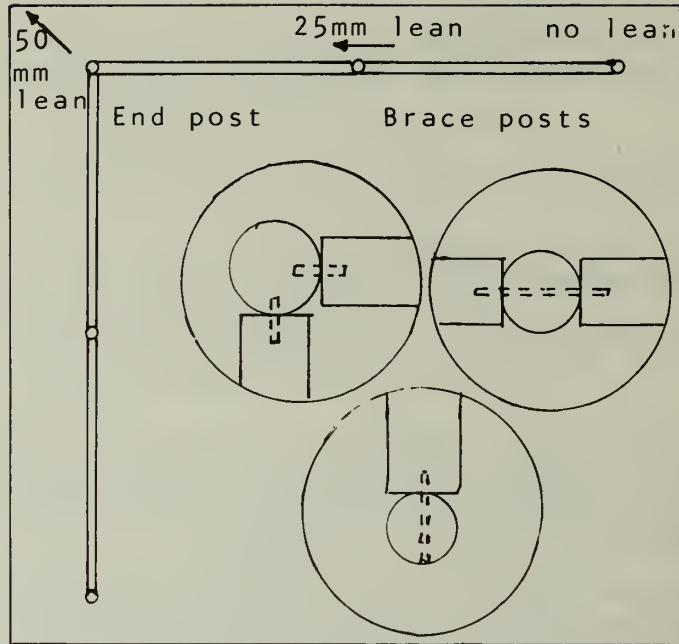


Figure 25. Corner Brace Assembly Showing Joint Detail using Pins

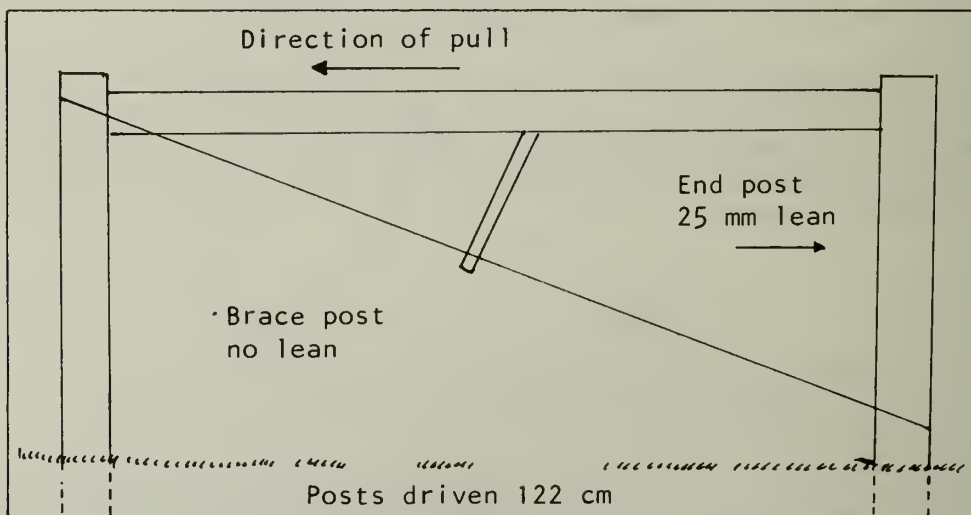


Figure 26. Single Span Brace Assembly

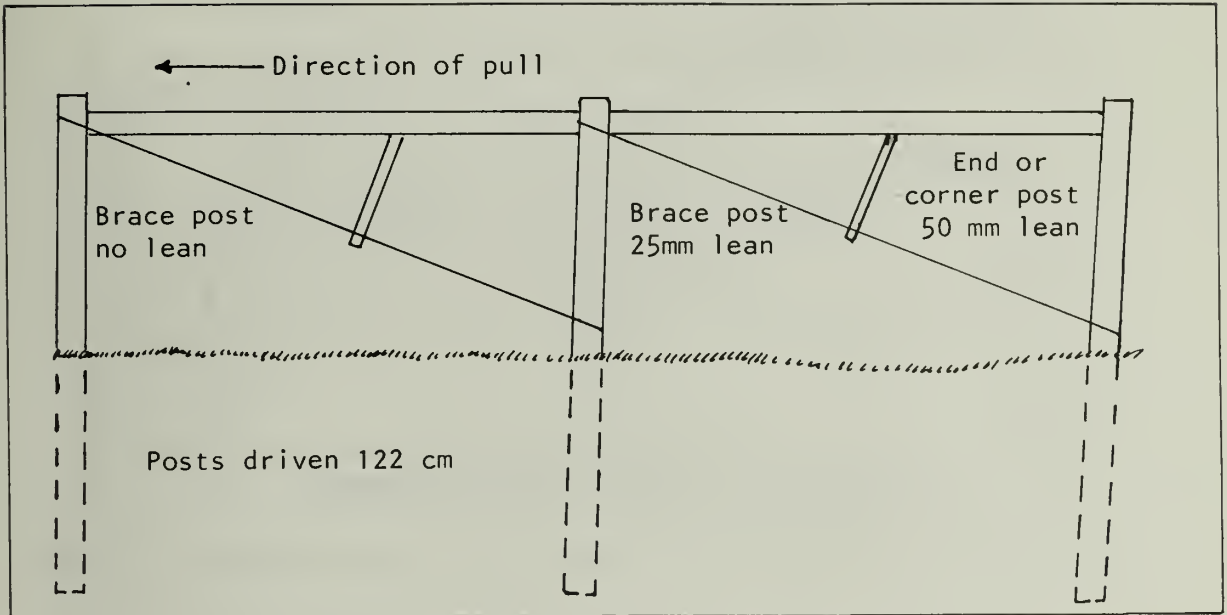


Figure 27. Double Span Brace Assembly

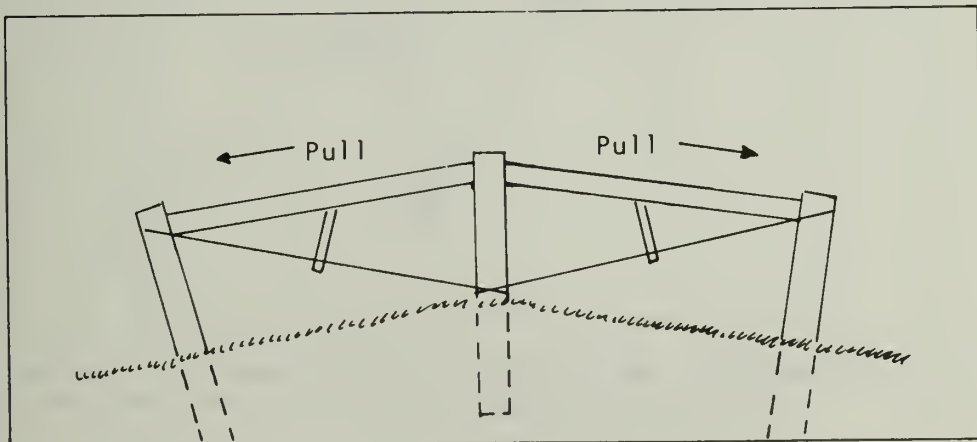


Figure 28. Double Brace Assembly for Rise Posts

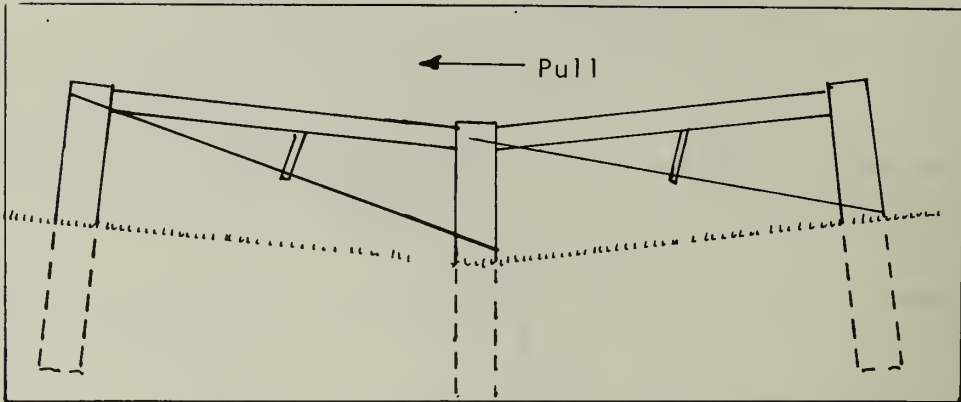


Figure 29. Double Span Dip Assembly

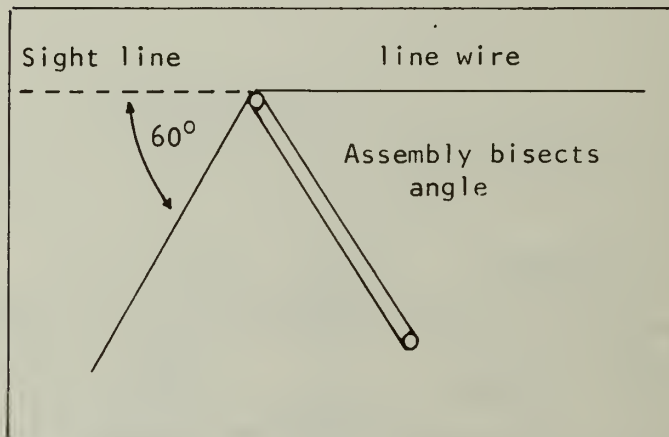


Figure 30. Medium Corner Brace Assembly for Change of Direction Greater than 20° but Less than 60°

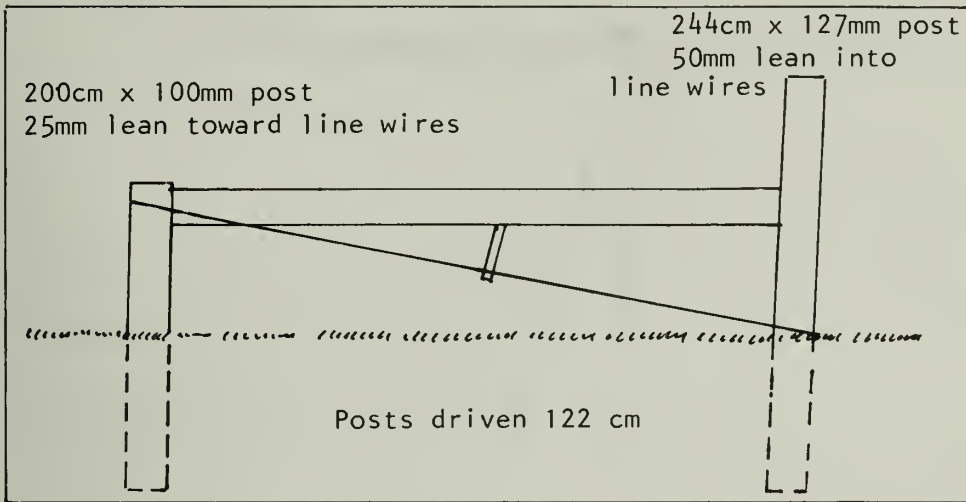


Figure 31. Medium Corner Brace Assembly (Fig. 30) Showing Construction

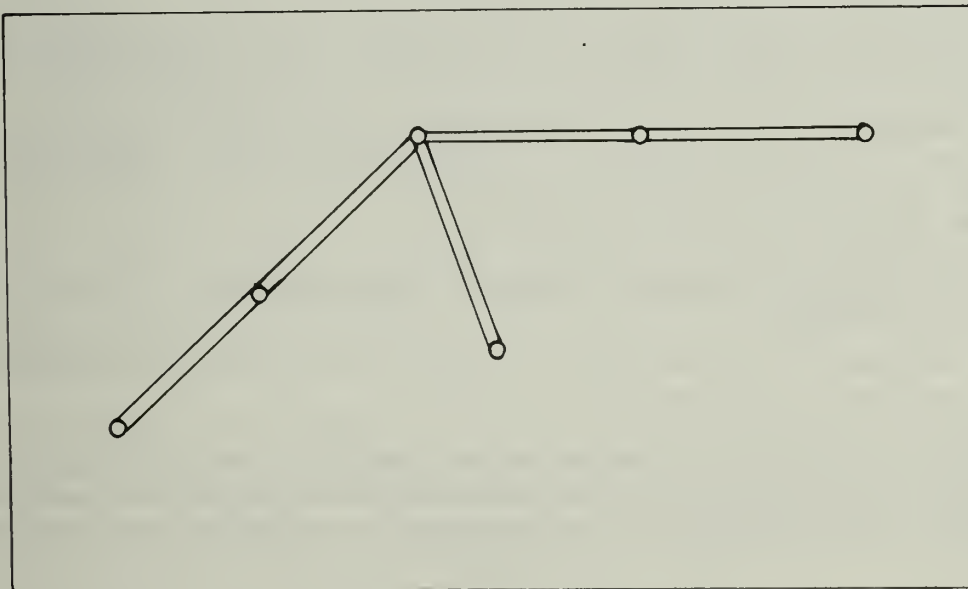


Figure 32. Double Brace Assembly for Shallow Corner in Soft or Boggy Soils

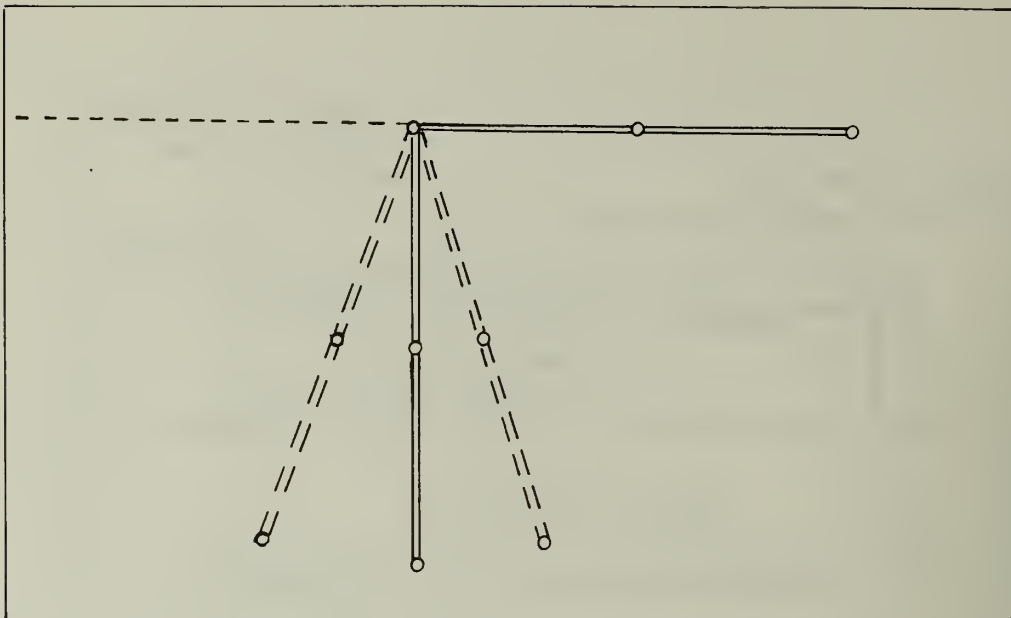


Figure 33. Double Brace Assembly for Angles Greater than 60°

Construction Procedure

Having driven the end posts, rise posts, corner posts and gate posts and strung and tensioned the guide wire, lay a 244 cm x 101 m top brace on the ground parallel to the guide wire and butt it against the end post to measure the location for driving the first brace post. Holding the guide wire aside, drive the post 122 cm deep with a 2.5 cm lean opposite the direction of pull of the line wires.

Note 1: All post holes may require pre-augering a 7 cm hole 90 cm deep.

Note 2: Allow 25 mm overlap for squaring of brace posts if spikes are used.

Again, holding the guide wire aside, measure with the second horizontal brace and drive the second brace post without any lean. When the guide wire is released it should just touch the posts.

If spiking, square the tops by removing not more than 13 mm of wood from the inside top of the brace and end posts and spike through the post into the ends of the horizontal brace.

If using pins:

- a). Measure up 118 cm from the ground on the brace side of the end post and drill a 9.5 mm hole 51 mm deep parallel to the line wires.
- b). Drive a 9.5 x 100 mm galvanized steel dowel pin 50 mm deep into the drilled hole in the end post.
- c). Measure up the first brace post 118 cm and drill a 9.5 mm hole through the post parallel to the line wires.
- d). Drive a 9.5 x 230 mm steel dowel pin through the post stopping when the pin emerges flush with the post surface.
- e). Mark, drill and drive the pin in the second brace post similar to the first.
- f). Drill a 9.5 mm diameter hole 51 mm deep in the centres of both ends of the horizontal top braces.
- g). Lift the first horizontal brace and position it on the pin protruding from the end post, align it with the pin on the first brace post and drive the pin 51 mm into the first top brace leaving 51 mm of the pin protruding to receive the second top brace.

Cut a 12.1 meter length of at least 12½ gauge fencing wire and bend a 15 cm loop in one end. Staple this or hook it over the protruding pin on the brace post. Maintaining hand tension on the wire, stretch a diagonal and wrap the wire around the end post under a horizontal staple and back over the pin or staple on the brace post. Complete two complete tight wraps in the same manner.

Pull as much slack up as possible and staple the wire to the brace post.

Facing the diagonal wires, opposite the livestock pressure side of the fence, insert a 38 mm x 50 mm x 60 cm treated twitch stick about 50 cm between the four diagonal wires, perpendicular to the wires so the end of the stick rests against the horizontal brace.

Maintaining this length, tilt the stick toward the post so that the stick clears the top brace, and pull the stick toward you to twist the wires together. Make six or eight complete revolutions twisting the wires and stopping with the stick in the upright position. Tilt the stick back so it rests against the top brace and cannot unwind.

Cut a length of wire and staple it over the end of the twitch

stick onto the top brace to secure the twitch stick.

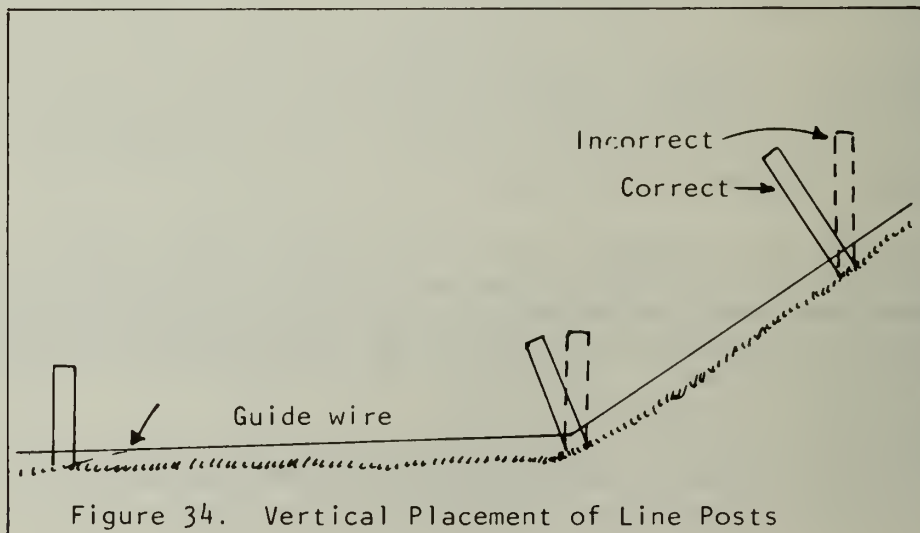
Bend the horizontal guide staples over the wire at the bottom of the end post and brace post to hold the wire.

Install the second top brace similarly to the first one.

Install diagonal wires similarly to the first one.

DRIVING LINE POSTS

1. Having set the end posts, and strung the guide wire, measure the location of posts by pacing or by stretching a tape and making a mark at the location of each post. Posts may be set 18 meters apart on level terrain or as far apart as the terrain will allow (up to 18 m) to maintain the wires parallel to the ground on uneven terrain.
2. Lay out a 198 cm x 100 mm line post at each location for driving.
3. Drive each post perpendicular to the soil surface to a 76 cm depth to maintain a straight fence. Take care that posts do not push the guide wire out of alignment. It is a good practice to allow 13 mm to 20 mm clearance between the driven post and the guide wire.
4. On uneven terrain, care must be taken to drive all posts perpendicular to the soil surface (Fig. 34). This maintains maximum stability in the soil and maintains the fence height.



5. Posts should generally be set on the downhill side of the wire on fences running across a slope and on the side of wire opposite the greater livestock pressure for more level situations.

STRINGING LINE WIRES

There are special considerations to make when working with wire. Barbed wire of course has barbs that catch and tear clothes and flesh and it will recoil when cut. High tensile wire is stiffer than barbed, is harder to bend and has a greater tendency to recoil than barbed wire. To cut wire, hold the needed end in one hand and step on the other end. If you must release a cut end secure it with something or push it several inches into the soil. Wear clothing that completely covers your arms and legs, heavy soled shoes, leather gloves and safety glasses.

The nature of barbed wire practically dictates that wires be strung one at a time to avoid tangling. Since high tensile smooth wire does not tangle, it is possible to string all wires at the same time.

To String Wire:

1. Load wire onto payout reels and beginning at end post position, on the livestock pressure side of the posts, tie off the wires beginning with the second from the bottom, or anchor the wire reel.
2. Slowly pay out the wires down the fence line staying as close as possible to the posts. Maintain enough tension on the wires to prevent loops and kinks from forming.
3. High tensile smooth wire may be periodically stapled on midpoint posts to guide the wire. Leave staples loose enough for wire to slide through them. (See page 47 on stapling).
4. Continue to pay out wire to about 152 cm beyond the far end post. Maintain the payout tension on the wires.
5. Wires should be positioned on posts with the use of tension sheaves for barbed wire and periodic loose stapling for high tensile smooth wire. This insures that wires will be parallel to the ground surface when tightened, with no need to pull up or push down the wires and thus change the tension during final stapling.

6. If an in-line wire strainer is not being used, cut the wire from the reel and attach a tensionmeter to it. If barbed wire is being used, tighten it to 272 kg, then relax to 136 kg and tie it off at the end post. Tighten high tensile wire to 136 kg and tie it off at the end post. If an in-line wire strainer is being used; tie the wire off at an end post without tightening it first. Staple all wires to the brace assembly.
7. If in-line wire strainers (Fig. 12, page 18) are used, cut off each wire from the reel, position all wires on the end post and tie them off using an end post knot or crimped sleeves. Do not tension.
 - a). Return to the midpoint of the span; working from the top wire, attach a wire puller about 122 cm from the post and pull the wire tight.
 - b). Cut the wire at the midpoint of the slack between the jaws of the wire puller. Install an in-line strainer by threading two compression sleeves onto the wire nearest the post, and slide them back about 30 cm. Thread about 15 cm of the wire through the holes in the shank of the in-line strainer and bend the wire back on itself. Slide the sleeves forward to catch the wire and crimp the sleeves.
 - c). Thread the line wire through the drum of the in-line strainer and cut off surplus wire close to the drum. Turn the drum to secure the wire and insert the ratchet pin. Continue turning to take up all slack. Remove the wire puller.
 - d). Continue as above for all wires using in-line strainers.
 - e). If an in-line tension indicator spring is to be used, attach it between the in-line strainer and the line wire in the second wire from the top.

TENSIONING LINE WIRE

Fences constructed with a tensionmeter are tensioned at end posts before tying off. If proper construction techniques were followed, wires were spaced, and fences were tensioned to 136 kg at 0°C or equivalent allowing for temperatures. These fences will remain well tensioned after the fence shifts to equilibrium, and no further tension adjustments need to be made.

The method for tightening fences utilizing in-line strainers is as follows:

1. Starting with the wire with the in-line tension spring, attach a handle or wrench and turn the drum of the strainer until the wire is taut and free from other wires.

If in-line tension springs are used, measure the coiled portion of the spring. Continue turning the drum until the coil is shortened 38 mm to 45 mm, which will give at least 113 kg tension on the wire.

2. Crank the remaining in-line strainers to about the same tension that was placed on the wire with the in-line tension spring. Check each wire against the spring tensioned wire by pulling toward you until the feel of the resistance is the same. With practice, this method is surprisingly accurate.
3. To tension wires without in-line springs, draw the fence taut by cranking up the in-line strainers. Continue cranking the strainer and check the tension by measuring wire deflection using the apparatus and spring scale shown in Fig. 13, page 20. After tensioning the first wire, additional wires can be tightened by feel, making final adjustments by measuring deflection pressures with the board and scale.
4. After all wires are tightened, staple all wires at their correct height on all posts following proper stapling techniques. Remove all wire sheaves before stapling.

STAPLING

Wire should be stapled to line posts after it has been tensioned.

Contrary to popular opinion, staples on line posts should never be driven tightly against the wire. Driving staples tightly increases friction on the wire and prevents even tension in long spans of wire. It also kinks the wire and results in short rigid spans with little or no elasticity to reduce the stress of livestock pressure against the fence. Tight staples also prevent movement of wires in response to temperature changes and, with imposed loads, stretching of the wires occurs, resulting in sagging or breakage.

Staples should be driven just tight enough so the wire could be removed and rethreaded through the arch of the protruding staple (Fig. 35).

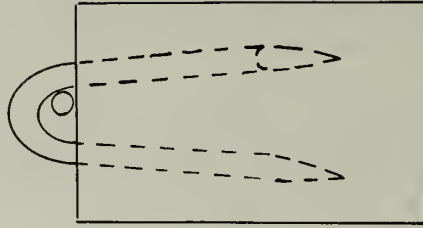


Figure 35. Proper Stapling

A major failure of wire fences is caused by staples pulling out. This could be the result of several factors, including:

1. Using the improper staple for the job;
2. Stapling wires on the wrong side of the posts for livestock pressure;
3. Wire stapled on inside of posts on curves;
4. Excessive tension in the wires;
5. Improperly driving the staples so there is little resistance to pulling.

Proper Technique:

1. Select the correct staples. The longer the staple the greater the hold. Tests show that 45 mm x 9 gauge staples driven in wood posts have 50% more resistance to being pulled out than 38 mm x 9 gauge staples driven into the same posts. For long life, all staples should be manufactured from galvanized wire, or hot-dip tumbler galvanized after forming. Staples should have slash cut points so the legs will bend with driving, giving the staple maximum holding power.
2. Staples should never be driven vertically into wood posts. Doing so can cause splitting along the grain of the wood, resulting in little holding power of the staple. Rotating the staple slightly off vertical straddles the grain, increasing the holding power of the staple.
3. Staples with slash points should be driven so their legs curve outwards as they penetrate the wood (Fig. 36). The slash cut acts as an asymmetrical wedge forcing the leg to curve away from the flat surface. Tests show that staples driven so that each leg curves away from the

vertical centre line have 40% more pull out resistance than staples driven incorrectly



Figure 36

When placing a staple over the wire against the post, rotate the staple slightly (20° off vertical) away from the flat surface of the point on the upper leg (Fig. 37).

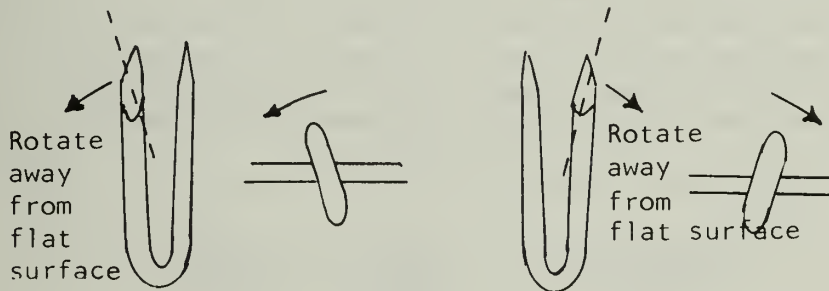


Figure 37

4. In dips, drive staples at an upward angle and on rises drive staples at a downward angle (Fig. 38). The wire is then pulling the staple in on the post instead of out.

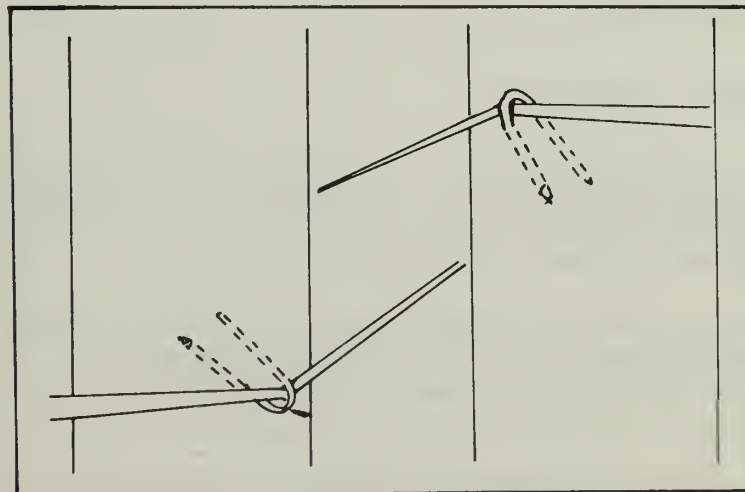


Figure 38.
Stapling rise
or dip wires

5. On very steep dips or rises, where there is considerable wire tension pulling on staples, double stapling is advantageous (Fig. 39).

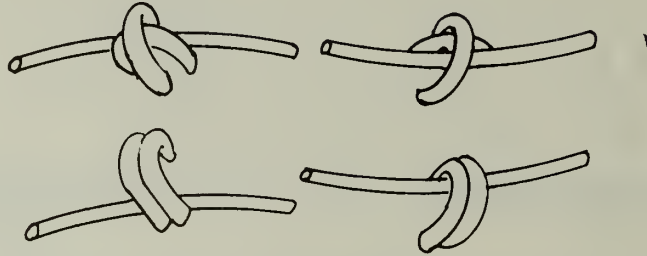


Figure 39. Double Stapling Rise or Dip Wires

6. When stringing and tensioning line wires around the outside of posts stapling can be used to reduce friction. Simply hang a staple over the securing staple and between the wire and the post so the line wire is sliding on the staple rather than the post (Fig. 40).

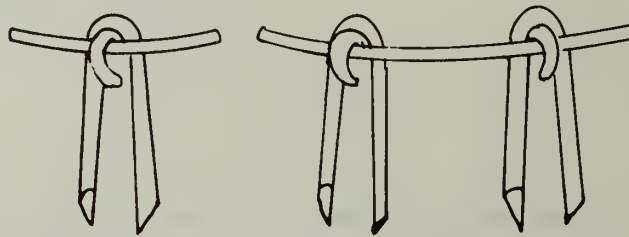


Figure 40. Stapling around Curves or Corners

INSTALLING DROPPERS

Dropper installation is the last operation performed in the erection of a line fence. Droppers are attached to the fence line wires after all wires are properly tightened and after final stapling has occurred.

Droppers, acting as wire spacers and load distributors, must be properly installed to function properly. To space wires correctly, they must remain vertical and hold the wire in

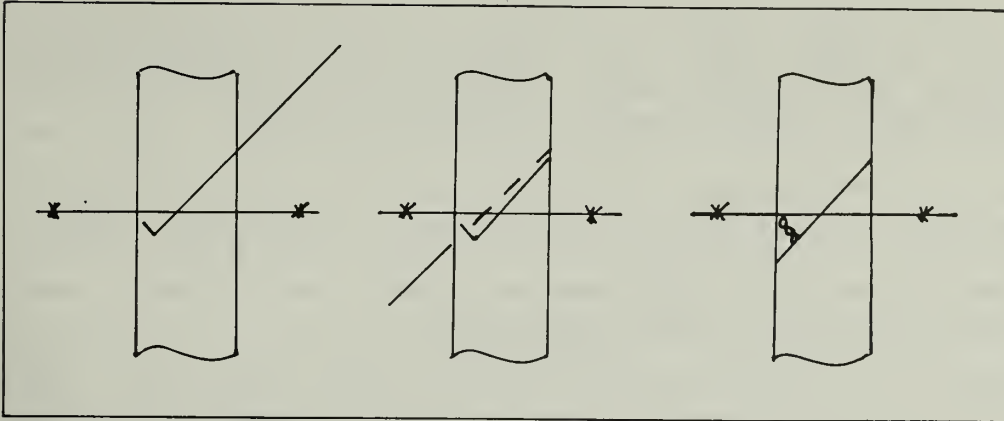


Figure 41. Single Wrap for Dropper Attachment.

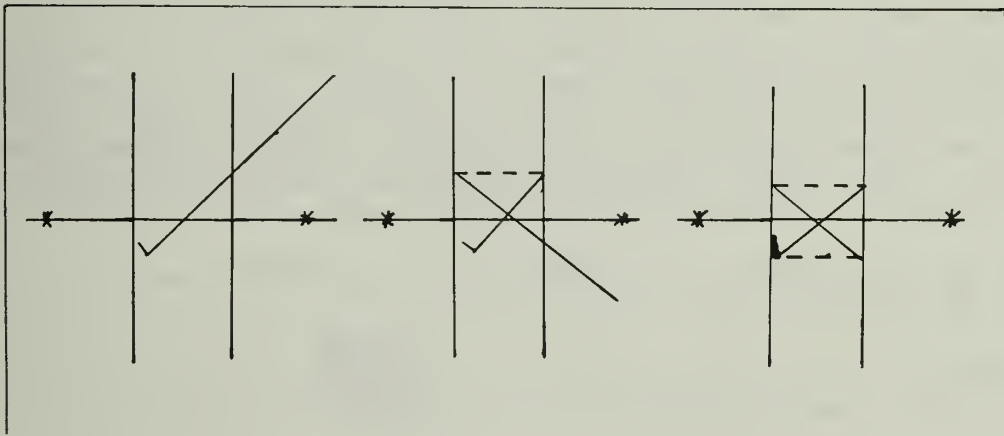


Figure 42. Figure Eight Wrap for Dropper Attachment.

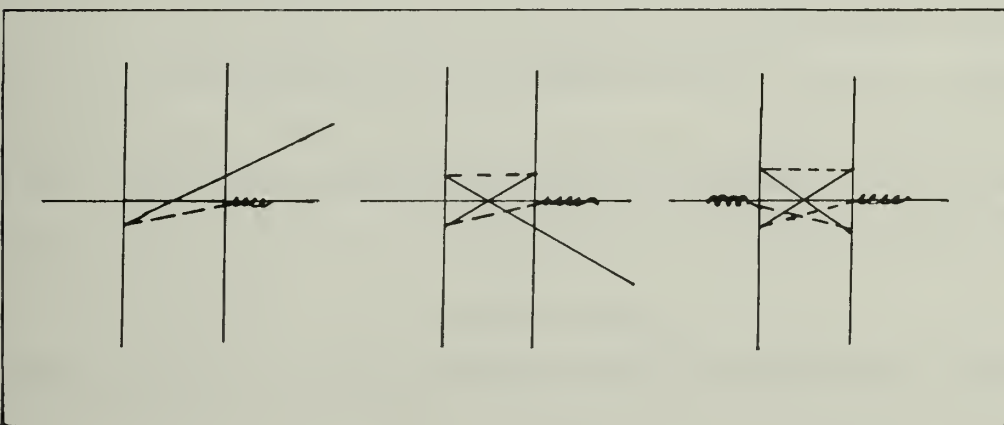


Figure 43. Figure Eight Wrap for Dropper Attachment to High Tensile Wire.

place. Thus, they must be attached relatively tightly to the wire. At the same time, they must be free to move with the wires while maintaining their position on the wires if they are to distribute a load of impact among the wires.

As previously mentioned, the number or spacing of droppers used is dependant upon livestock pressure on the fences. The greater the livestock pressure on a fence the greater the requirement that wire spacings be rigidly maintained, thus the more closely spaced droppers should be.

SUSPENSION. On fences where the wires are relatively close to the ground (eight or more wires) it is not recommended that droppers touch the ground. This allows droppers to move with the wire on impact.

On fences where the bottom wire is 30 cm or more off the ground and where there is small livestock pressure on the bottom wires, it is recommended that a dropper (or a post) be in contact with the ground every 6 to 9 m. Thus, in an 18 m span, with droppers every 3 m, every second or every third dropper would be resting on the ground. These droppers drag with pressure of small livestock (calves) on the bottom of the fence and prevent overturning of the fence.

METHODS OF ATTACHMENT. Droppers may be stapled, wired, clipped or twisted onto line wires.

1. Droppers that snap on or use clips are easy to install without prior instruction.
2. Spiral twisted wires are placed so the legs of the spiral straddle the top wire. Very slight downward pressure and guidance by the technician results in the dropper twisting itself onto the fence. Remember, these droppers disfigure with livestock pressure.
3. Wooden droppers of sufficient size can be stapled to the wires.
4. Knots for use when droppers are attached with wire, are depicted in Figures 41, 42 and 43.

G A T E S

Gates are a requirement of all fences. All gates should be:

1. located to enhance, not hinder, farm management;
2. at least as high as the fence;
3. wide enough to permit passage of the widest machinery;
4. level enough, and hinged, to permit free swinging;
5. as long lived as the fence.

The wider the gate, the greater its tendency to pull over the post on which it is hung. Because of this, gates should be installed on end or brace posts to which line wires have been tied off. Posts should be at least 244 cm x 152 mm driven 122 cm into the ground. Gates should be situated several feet from corners or perpendicular fences to facilitate machinery movement. It may be necessary to offset gates in boundary fences along busy roadways. In such cases, panels of boards are better than short sections of wire fence.

The installation of gate hinge pins parallel to fence line wires does not allow the gate to swing back against the fence. Installing the pins 45° off parallel, on the side of the post from which you wish the gate to swing, will allow the gate to swing fully back against the fence (Fig. 44)

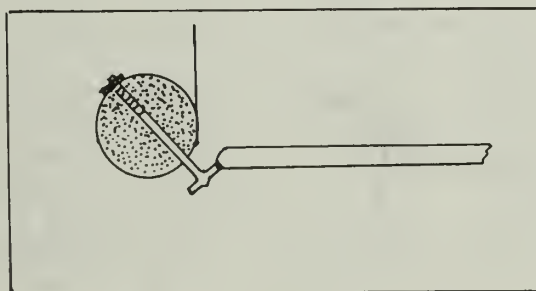


Figure 44. Hanging Gate at 45° Allows it to Swing Fully Back Against Fence.

A hinged wire gate (Fig. 45) designed by S. Clark Martin at the University of Arizona is constructed as follows:

1. Tightly fasten the end pieces to the diagonal so the frame is relatively rigid;
2. Hang the frame on the hinges or pivot;
3. Fasten the first wire from the centre of the latch end to the centre of the hinge end.

4. Tighten the first wire to hold the latch end at the desired height;
5. Attach remaining wires, pull them tight enough to hold the latch end vertical;
6. Attach vertical supports as needed;
7. Tighten the frame so it is rigid;
8. Materials required:
 - a. The diagonal and end pieces can be steel pipe, wooden rails or a combination of the two;
 - b. The hinge can be two bolted pivots on the gatepost or one on the post and a buried pipe in the ground;
 - c. Joints between the diagonal and end pieces can be welded on tabs, flattened pipe, or screwed on angle iron braces for wooden components. They must, however, be tight.

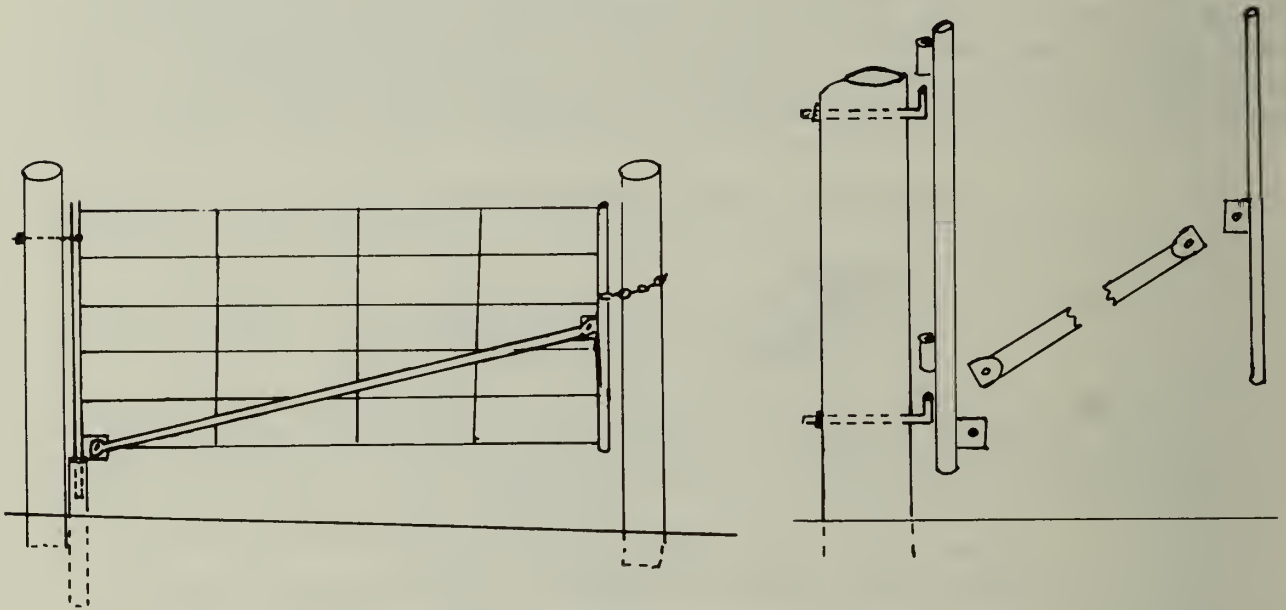


Figure 45. Hinged Wire Gate.

S A F E T Y

Anyone building a wire fence is subject to cuts and scratches inflicted by the wire. These can be magnified through carelessness when working with high tension fences. Safety precautions should always be followed:

1. Wear tough clothing that will not tear easily and that will not readily catch on wire ends or barbs.
2. Wear heavy duty, gauntlet type, leather gloves which fit snugly.
3. Wear long pants and work boots with heavy soles to protect feet and legs.
4. Have the right tools for the job, keep tools in good working order and follow instructions for tool use.
5. Wear eye protection when cutting or tensioning wire and when driving nails or staples.
6. Use proper shields on power equipment.
7. Use a nail apron or tool bag to carry nails, staples and tools.
8. Wear a hard hat and ear protection when operating a post pounder.
9. Use driving caps on posts to prevent splintering.
10. Keep children and livestock away from fencing operations.
11. When working with treated posts or lumber, wear protective clothing. Some persons are allergic to chemicals.
12. Never use unsafe shortcuts.
13. Keep the work area free from debris; pick up all pieces of wire, nails, staples etc. to protect equipment, livestock and people.

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ACKNOWLEDGMENT

The author gratefully acknowledges the assistance of Dr. J. W. Zahradnik, Bio Resource Engineering Department, University of British Columbia, who developed the basic principles by conducting a research contract "Study on Cost Reduction of Rangeland Fence Construction in British Columbia" funded by Research Branch, Agriculture Canada.

A P P E N D I X

As with any new technology, sources of materials may be initially hard to locate. Because of this, the following known suppliers and suggestions are referenced. Mention of a product or supplier does not constitute a recommendation by Agriculture Canada nor by the author.

Wire suppliers:

1. Check your phone book for fencing companies and steel companies.
2. Koppers International Canada Ltd., 8335 Meadow, Burnaby, B.C.
3. Chilco Industries Ltd., P.O. Box 252, Maple Ridge, B.C.
V2X 7G1
4. Sulicher Canada Limited, P. O. Box 183 Maple Ridge, B.C.
V2X 7G1.
5. Davis Wire Industries Limited, 960 Derwent Way, New Westminster, B.C.
6. Tree Island Steel, P. O. Box 50, New Westminster, B.C.
V2L 4Y1.

Hardware suppliers:

1. Check your phone book for fencing companies.
2. Koppers International Canada Ltd., 8335 Meadow, Burnaby, B.C.
3. Chilco Industries Ltd., P. O. Box 252, Maple Ridge, B.C.
V2X 7G1
4. Sulicher Canada Limited, P. O. Box 183 Maple Ridge, B.C.
V2X 7G1.
5. Industrial supply firms can supply swagers and compression sleeves, but may have to order them.

Sheet metal droppers:

1. Merrit Machine Works Ltd., 2175 Coldwater, Merritt, B.C.
2. Spruceview Metalform Ltd., Innisfail, Alberta.

CONVERSION FACTORS

Metric units	Approximate conversion factors	Results in:
LINEAR		
millimetre (mm)	× 0.04	inch
centimetre (cm)	× 0.39	inch
metre (m)	× 3.28	feet
kilometre (km)	× 0.62	mile
AREA		
square centimetre (cm ²)	× 0.15	square inch
square metre (m ²)	× 1.2	square yards
square kilometre (km ²)	× 0.39	square mile
hectare (ha)	× 2.5	acres
VOLUME		
cubic centimetre (cm ³)	× 0.06	cubic inch
cubic metre (m ³)	× 35.31	cubic feet
cubic metre (m ³)	× 1.31	cubic yards
CAPACITY		
litre (L)	× 0.035	cubic foot
hectolitre (hL)	× 22	gallons
hectolitre (hL)	× 2.5	bushels
WEIGHT		
gram (g)	× 0.04	oz avdp
kilogram (kg)	× 2.2	lb avdp
tonne (t)	× 1.1	short tons
AGRICULTURAL		
litres per hectare (L/ha)	× 0.089	gallons per acre
litres per hectare (L/ha)	× 0.357	quarts per acre
litres per hectare (L/ha)	× 0.71	pints per acre
millilitres per hectare (mL/ha)	× 0.014	fl. oz per acre
tonnes per hectare (t/ha)	× 0.45	tons per acre
kilograms per hectare (kg/ha)	× 0.89	lb per acre
grams per hectare (g/ha)	× 0.014	oz avdp per acre
plants per hectare (plants/ha)	× 0.405	plants per acre

630.72
C759
C 83-22
OOAg
c.3

Quinton, D. A.
High tension high tensile
fencing



